Journal of Radiotherapy in Practice

cambridge.org/jrp

Patients' perspective on the use of mobile applications for the provision of supportive care in radiotherapy

Maria Stella Sammut and Susan Mercieca

Department of Radiography, Faculty of Health Sciences, University of Malta, Msida, Malta

Original Article

Cite this article: Sammut MS and Mercieca S. (2023) Patients' perspective on the use of mobile applications for the provision of supportive care in radiotherapy. *Journal of Radiotherapy in Practice*. **22**(e115), 1–6. doi: 10.1017/S1460396923000407

Received: 20 August 2023
Revised: 20 October 2023
Accepted: 26 October 2023

Keywords:
mobile health; supportive care; radiotherapy; side effect management

Corresponding author:
Susan Mercieca;
Email: susan.mercieca@um.edu.mt

Abstract

Introduction: This study aimed to investigate the patient's perception of the usefulness and limitations of a mobile application as part of the supportive care provided to patients undergoing radiotherapy.

Methods: Patients undergoing radiotherapy between February 2023 and March 2023 at a local oncology hospital ($n = 150$) were invited to complete a questionnaire that assessed the patient's smartphone knowledge, willingness to use an app during radiotherapy, perceptions of the usefulness of specific app features, and barriers to using such applications. For quantitative analysis, frequencies were obtained for all areas of interest, and the results were correlated with the patient's demographics.

Results: Of the 39 participants who completed the questionnaire, 82·1% had a smartphone device, 59% could use their smartphones with minimal to no help and 41% had not used their smartphones for medical purposes before. However, 79·5% of patients showed a strong interest in using a mobile app during radiotherapy. Age, gender and level of education had no significant impact on the acceptability of using the mobile application for radiotherapy purposes.

Conclusion: Overall, the findings indicate that most patients have access to mobile technology and are willing to use the mobile app as an additional supportive care tool.

Introduction

Radiotherapy is a common treatment for cancer. However, although radiotherapy is a highly effective treatment, it can also damage normal tissue, leading to side effects. Therefore, the provision of supportive care during treatment and beyond is essential to enable patients to manage and minimise these side effects, enhance their overall well-being and improve their quality of life [1].

Supportive care for patients undergoing radiotherapy is commonly delivered through treatment review clinics overseen by a collaborative team of experts. These clinics allow patients to discuss their disease progress and physical and emotional well-being with healthcare professionals. Nevertheless, these review clinics are not without their limitations. However, the scheduled intervals for these clinics may miss the rapid changes in disease progression and side effects that can occur after treatment. Moreover, the constrained time slots allocated to each patient by clinicians could result in hurried appointments, potentially depriving patients of the comprehensive attention they require to address their concerns. As a result, during these review clinics, the treatment-related side effects are often under-reported, and some important supportive care needs of the patients remain unrecognised [2,3]. In order to address these issues, several oncology centres are now introducing mobile health (mHealth) technologies to support patients during treatment and beyond.

mHealth involves using mobile devices such as smartphones, tablets, wearable devices, and other wireless technologies to deliver healthcare-related services [4]. Although a wide range of mHealth technologies are available on the market, until recently, very few applications have been available for patients receiving radiotherapy. However, the coronavirus pandemic has increased the reliance on telemedicine and mHealth technologies to provide follow-up services to mitigate the spread of the disease [5]. As a result, in response to the pandemic, several radiotherapy equipment manufacturers have now integrated mHealth solutions within their radiotherapy workflows, while some other oncology centres have developed their own solutions [6–10]. These mHealth applications can be easily installed on patients' mobile phones and serve as platforms to deliver information, facilitate the reporting of electronic patient-reported outcome measures (ePROMS), offer symptom feedback, conduct video conferencing and manage appointments effectively. Studies have shown that ePROMS could be used to facilitate the collection of structured data on the treatment-related side effects experienced by the patient [9,10]. This data could then be used to enhance symptom monitoring, offer timely interventions and conduct long-term data analytics to improve patient care.

However, although mHealth technologies can empower patients to take charge of their health and facilitate the delivery of personalised care, they are not without their limitations [4,8,11,12]. It is important to note that some patients, particularly the elderly and those from a low socio-economic and educational background, may not have access to this technology and/or may lack the knowledge to use it [4,13]. Therefore, full reliance on this technology can create a digital divide that may exclude some populations from benefiting fully. Additionally, the accuracy of health measurements and data collected through mobile apps can vary due to device quality and user input errors. Data security and privacy concerns are also prominent, as sensitive health information transmitted through these apps could be vulnerable to breaches. The effectiveness of mHealth interventions also relies heavily on user engagement and motivation, which can decline over time and can vary widely among patients [14]. Finally, the absence of in-person interaction might hinder the establishment of a strong patient–provider relationship, potentially affecting the quality of care.

The successful and equitable integration of mHealth technologies within healthcare depends on developing services to meet the distinct needs of the patient population [4]. Although several studies assessed the feasibility of introducing this technology in clinical practice, research examining the patients' perception of the benefits of introducing a mHealth service designed specifically to support patients undergoing radiotherapy remains limited. Furthermore, the absence of such a service in Malta underscores the necessity to evaluate the patient's perspective on the feasibility of implementing this technology within the local oncology setting to supplement the current supportive care services provided at the local oncology centre. Therefore, this study aimed to make use of a questionnaire to assess the patients' perspectives on the use of mobile applications for the provision of supportive care in radiotherapy.

Methodology

Research design

This study employed a descriptive, cross-sectional, non-experimental and quantitative research design using a self-designed questionnaire.

Ethical considerations

Ethical approval was sought and acquired from the University Research Ethics Committee (UREC) of the University of Malta (FHS-2022-00178).

Data collection tool

The data collection tool consisted of an adaptation of a pre-existing questionnaire designed by El Shafie et al. [11]. Several changes were made to the questionnaire to align better with the aim of the study and the local oncology setting (Supplementary Data 1). The questionnaire consisted of five sections. The initial section enquired about the demographics of the participating patients. Subsequently, the second section delved into the utilisation of smartphone technology among patients. The third section aimed to gain insights into the adoption of smartphone technology for health-related purposes. The fourth segment further probed into the participants' technical familiarity with smartphone usage. Finally, the concluding section employed a Likert scale ranging from 1 (not useful) to 5 (very useful) to gauge the perceived efficacy of distinct mHealth features that could be used to support patients during their treatment. In order to make it easier for the participants to visualise the application, some print screens of a prototype radiotherapy mobile application were included in this section. The last section of the questionnaire enquired about other issues related to the deployment of this service, including security issues, use of data for research purposes, side effects reporting frequency and preferred communication methods with healthcare professionals. The final questionnaire was also translated into the Maltese language.

The questionnaire was tested for content validity to ensure the relevance of the questions in relation to the aims and objectives of the study. Four experts in the field (three radiographers and one lecturer) were asked to rate the relevance and clarity of each question using a Likert scale of 1 (not relevant / not clear) to 4 (very relevant / very clear). In addition, the experts were asked to provide suggestions to improve the questionnaire. The content validity index (CVI) was calculated by summing up the number of experts who rated the question as relevant or clear (rating 3 or 4) divided by the total number of experts [15]. The average CVI for the tool was then calculated. The average CVI for the tool was 0·97. However, based on the feedback obtained from the four experts, three questions were reworded to improve clarity.

Data collection process

All new patients having treatment at the radiotherapy department between February 2023 and March 2023 were invited to complete the questionnaire by a radiographer while waiting for one of their radiotherapy appointments. The patients willing to participate in this study were provided with a paper copy of the questionnaire. We opted for a paper format of the questionnaire instead of electronic to enhance the response rate, as it was considered more convenient for patients to complete while waiting for treatment. Moreover, we believed that patients who can use electronic tools were more likely to have favourable opinions on mHealth. This raised the concern that employing an electronic tool could potentially introduce bias to the research findings.

Data analysis

The Statistical Package for Social Science (SPSS) version 23 was used for statistical analysis. The Chi-square test was used to assess the association between the demographic variables (gender, age group and level of education) and categorical variables, while the Kruskal–Wallis test was used to evaluate the impact of the demographic variables on the continuous variables. For all statistical tests, a p-value below 0·05 was deemed statistically significant.

Results

Characteristics of the participants

During the 6-week data collection period, 150 new patients received treatment at the local oncology hospital and were invited by intermediaries to participate in the study. Out of these patients, 39 (26%) responded to the questionnaire. The demographic characteristics of the participants are summarised in Table 1. The male-to-female ratio of the whole cohort was about 5:3. The majority of the participants were aged between the 66 to 75 years category ($n = 14$, 35·9%) and the 56 to 65 years category ($n = 12$, 30·8%), which reflects the typical incidence of cancer within the

https://doi.org/10.1017/S1460396923000407 Published online by Cambridge University Press

Table 1. Characteristics of the participants

Q	Factor	*N* (%)	Smartphone owners	*p*-Value
1	Gender			
	Male	25 (64,1%)	20 (80%)	0·656
	Female	14 (35·9)	12 (85·7)	
2	Age			
	≤ 55 years	6 (15·4%)	6 (100%)	0·221
	56–65 years	12 (30·8%)	10 (83·3%)	
	66–75 years	14 (35·9%)	12 (85·7%)	
	>75 years	7(17·9%)	4 (57·1%)	
3	Level of education			
	Primary	6 (15·4%)	3 (50%)	0·009*
	Secondary	11(28·2%)	7 (63·6%)	
	Post-Secondary	14 (35·9)	14 (100%)	
	Tertiary	8 (20·5%)	8 (100%)	
4	Treatment site			
	Brain	2 (5·1%)	N/A	N/A
	Head and neck	7 (17·9%)		
	Prostate	16 (41·0%)		
	Gynaecological	2 (5·1%)		
	Abdomen	3 (7·7%)		
	Breast	9 (23·1%)		
	Total	39 (100%)	32 (82·1%)	

*indicates statistically significant.

general Maltese population. The most common educational level achieved by the participants was post-secondary ($n = 14$, 35·9%). The prostate was the most common area of treatment among participants ($n = 16$, 41%), while brain ($n = 2$, 5·1%) and gynaecological cancers were the least common ($n = 2$, 5·1%).

Most participants ($n = 32$, 82·1%) owned a smartphone device. Although patients above 75 years old were less likely to own a smartphone, the difference was not statistically significant. However, patients with higher educational levels were significantly more likely to own a smartphone.

Habits of smartphone usage

Table 2 summarises the habits of smartphone usage. The Android operating system was the most commonly used system ($n = 26$, 81·3%), followed by the iPhone ($n = 5$, 15·6%). Of the 32 patients who owned a smartphone, 20 (62·5%) used WIFI and mobile data connections.

Most patients were also regular users and generally checked their smartphones for notifications at least once every 2 h ($n = 13$, 40·6%) or more frequently ($n = 14$, 43·8%). Only five (15·7%) patients checked their smartphones once every 12 h or once every 2 days. Most patients used their mobile phones as a means of communication, using either voice calls ($n = 15$, 46·9%) or instant messaging ($n = 17$, 53·1%).

Some of the participants ($n = 14$, 43·8%) were already using some mHealth applications on their smartphones mainly for fitness purposes ($n = 8$, 25·0%), in conjunction with a smartwatch ($n = 2$, 6·3%) or to remind them to take medications ($n = 3$, 9·4%).

Table 2. Habits of smartphone usage amongst the participants who owned a smartphone ($n = 32$)

Q	Habits	*N*(%)
6	Operating system	
	Android	26 (81·3%)
	iPhone	5 (15·6%)
	Don't know	1 (3·1%)
7	Internet connectivity	
	Both WIFI and mobile data	20 (62·5%)
	WIFI only	8 (25·0%)
	Mobile only	4 (12·5%)
	None	0 (0%)
8	Notification checking	
	Once every 30 min	8 (25%)
	Once every 60 min	6 (18·8%)
	Once every 2 h	13 (40·6%)
	Once every 12 h	3 (9·4%)
	Once every 2 days or longer	2 (6·3%)
9	Mobile functionalities used	
	Voice calls	15 (46·9%)
	Instant messaging	17 (53·1%)
	Taking pictures	13 (40·6%)
	Web browsing	13 (40·6%)
	Social media	17(53·1%)
	Intensive app use with more than 10 apps downloaded	4 (12·5%)
10–11	Use of mHealth apps	
	Step tracker/ fitness application	8 (25·0%)
	Smartwatch	2 (6·3%)
	Medication reminders	3 (9·4%)
	None	19 (59·3%)

Knowledge and willingness to get support while using the smartphone

The majority of the participants who owned a smartphone ($n = 32$) rated their smartphone skills as basic ($n = 14$, 43·8%) or average ($n = 9$, 28·1%). Only one of the smartphone owners stated that they could not use it ($n = 1$, 3·1%). The rest of the smartphone owners rated their skills as either advanced ($n = 3$, 9·4%) or above average ($n = 4$, 12·5%). Only one (3·1%) of the smartphone users stated that they were not willing to ask for help to make use of the radiotherapy application.

Out of the seven participants who did not own smartphones, all of them mentioned their inability to use such devices. However, among these individuals, five expressed their willingness to seek help from a family member or friend to access the radiotherapy application. In contrast, two participants mentioned their reluctance to ask for assistance, and one of them specifically noted that they found none of the smartphone features to be useful.

https://doi.org/10.1017/S1460396923000407 Published online by Cambridge University Press

Table 3. Mean ± standard deviation score for the perceived ability and need for assistance using a smartphone. The usability was rated using a score of 1 to 5, whereby 1 indicates 'no skills' and 5 indicates 'advanced skills'. Similarly, the need for assistance was rated using a score of 1 to 5, whereby 1 indicates 'never' and 5 indicates 'always'

Factor	Categories	Mean ± SD score for "the ability to use a smartphone"	*p*-Value	Mean score ± SD for "need of assistance to use a smartphone"	*p*-Value
Overall		2·51 ± 1·233		2·85 ± 1·182	
Gender	Male	1·36 ± 0·048	$p = 0·607$	1·36 ± 0·048	$p = 0·353$
	Female				
Age	55 years or less	2·56 ± 0·968	$p = 0·333$	2·56 ± 0·968	$p = 0·039^*$
	56–65 years				
	66–75 years				
	76 years or more				
Education level	Primary	2·62 ± 0·990	$p = 0·015^*$	2·62 ± 0·990	$p = 0·238$
	Secondary				
	Post-Secondary				
	Graduate				

$^*p < 0·05$.

Gender had no impact on the mean usability and assistance score. However, patients with a higher educational background encountered less difficulty using a smartphone ($p = 0·015$), and older patients tended to need more assistance using a smartphone ($p = 0·039$) (Table 3).

Readiness to use a mHealth application throughout their radiotherapy (questions 16 to 22)

Irrespective of whether or not they owned a smartphone, the majority of the participants (79·5%, $n = 31$) found the introduction of a mobile app as an additional supportive care tool during their treatment and beyond as helpful or very helpful, while the remaining 20·5% ($n = 8$) stated that they were not sure. Gender ($p = 0·017$), age ($p = 0·468$) and level of education ($p = 0·302$) had no impact on the perceived usefulness of introducing a radiotherapy app. The participants were also asked to rate the usefulness of specific mHealth features commonly used on oncology apps using a scale of 1 'Not useful' to 5, 'Extremely useful'. As shown in Table 4, all features received a mean score of 3 or higher. The 'alert my doctor when experiencing severe side effects' feature received the highest score, while the 'communicating with my doctor via video conferencing' received the lowest score. However, the response for the latter feature also had the largest standard deviation, indicating that the perceived usefulness of this feature varied widely.

Practical issues related to the deployment of this service

The majority of the participants ($n = 24$, 61·5%) were willing to ask for help if they encountered difficulty using the app, while only three (7·7%) participants stated that they would not be willing to ask for help. The rest of the participants ($n = 12$, 30·1%) stated that they do not need assistance to use mobile apps.

The participants' preferred frequency to respond to app-based inquiries about their well-being or general symptoms varied, with 35·9% ($n = 14$) willing to do so weekly, 23·1% ($n = 9$) on alternate days, 12·8% ($n = 5$) daily, 12·8% ($n = 5$) at the beginning and end of therapy or every other day, and 15·4% ($n = 6$) as required. In case the physician noted that they were experiencing severe side effects based on their submitted reports, the majority ($n = 30$, 76·9%) of the patients stated that they preferred to be contacted via phone. A small number of participants wanted to be contacted via email ($n = 2$, 5·1%), text message ($n = 2$, 5·1%) or through the app ($n = 4$, 10·3%).

Table 4. Mean rating score for the proposed radiotherapy app features whereby a score of 1 indicates not useful and a score of 5 indicates extremely useful

Feature	Mean score	±SD
Alert my doctor if I'm experiencing severe or abnormal treatment side effects.	4·05	0·972
Keep track of my appointments	4·03	0·811
To keep in touch with my doctor after treatment	3·95	0·972
Obtain advice on how to manage any side effects related to treatment	3·92	0·957
Remind me to take medications or prepare for treatment	3·85	1·065
Obtain information about radiotherapy and hospital services.	3·82	0·79
Report symptoms experienced during and after my radiotherapy treatment	3·79	1·031
Communicate with my doctors via video conferencing	3·46	1·274

The majority ($n = 35$, 89·7%) of the patients agreed to have their anonymised data collected through this app to be used for research purposes. Concerns regarding data security were voiced by 51·3% ($n = 20$) of patients. The remaining 20·5% of patients ($n = 8$) were undecided, and 28·2% ($n = 11$) stated they had no reservations.

Discussion

The successful and equitable integration of mHealth technologies within healthcare relies on the creation of tailored services that

https://doi.org/10.1017/S1460396923000407 Published online by Cambridge University Press

effectively address the unique requirements of the patient population [13]. Therefore, in this study, we have explored the feasibility of developing a mHealth app to address the supportive care needs of cancer patients undergoing radiotherapy treatment in Malta.

Access to mobile technology is a key factor that makes the usability of mHealth apps feasible. Traditionally, age used to be seen as a barrier to accessing smartphone technology [16]. In recent years, the use of smartphone technology has increased significantly across all age groups, including the elderly population [17]. Our findings indicate that although the ownership of smartphones decreased with age, the difference was not statistically significant. Consistent with previous studies, patients with higher education levels were significantly more likely to own smartphone technology and encountered less difficulty using a smartphone [13,18]. However, in contrast with the findings of El Shafie et al. [11] in our study, the influence of education on smartphone ownership appears to outweigh that of age. The use of smartphones amongst the elderly population varies widely across countries [16]. Apart from sociodemographic factors, cultural factors, social networks and national policies were also found to have a big impact on engagement with digital technology [16,17]. Therefore, the deployment of mHealth services should be adapted according to the specific needs of the population being targeted. It is important to note that even when patients have the technology and knowledge to use smartphones, they may lack the necessary health literacy or physical abilities to understand medical content. However, in contrast to traditional information methods like leaflets, mobile technology offers adaptability to cater to diverse user needs. For instance, multimedia elements can be integrated to accommodate patients with challenges such as low literacy, visual impairment or hearing difficulties [19]. Furthermore, mobile technology allows for on-demand information delivery, ensuring users can access relevant and current information precisely when they require it. As a result, this technology has the potential to improve access to medical information among patients with low health literacy.

In our study, the majority of the respondents had access to smartphones. However, their perceived ability to use the technology, as well as the smartphone features used, varied widely. Most patients used their smartphones as a communication tool and checked their smartphones regularly for notifications. Regular use of smartphone technology is essential for medical staff to reach patients via this technology. It is important to note that most of the respondents owned either a smartphone based on standard operating systems such as Android or iPhone; they were not heavy app users and generally made use of apps that could run smoothly, even on older phones. Elderly patients may find it harder to remain up-to-date with the latest smartphone technology. Therefore, the design of the mHealth app should kept as simple as possible and should be based on a text service and make minimal use of data to ensure that it can run smoothly even on older devices. Alternatively, access to the mHealth app could be offered through a browser that can be accessed on mobile phones.

An important finding of the study was that most of the respondents who did not own a smartphone still displayed a keen interest in utilising the radiotherapy app. Similarly to the study of El Shafie et al., individuals who lacked smartphone ownership in our research were willing to seek assistance in gaining access to this technology, thus highlighting the need to involve caregivers to aid patients unable to utilise the app independently [11]. On the whole, these findings are encouraging, as they show that the use of mobile apps does not exclude individuals who lack access or knowledge of such technology. Nevertheless, not all patients have a readily available social support network. Thus, it is important to emphasise that this technology should complement rather than replace traditional services. Healthcare professionals should empower patients to make informed choices about the use of mHealth services. Moreover, healthcare professionals should offer training to ensure that patients understand the importance of safeguarding their personal data. It is ultimately up to the patient to decide with whom they want to share their medical information. As shown by Vulpe et al. [17], the use of mobile phones is becoming more established, even among older people. In the near future, almost all elderly patients will have access to technology. The demand for mHealth services amongst the population is expected to increase as patients are increasingly more willing to manage their health and are now demanding more efficient access to healthcare resources. Not surprisingly, some patients in our study were already using several mHealth technologies aimed at maintaining a healthy lifestyle.

Since there is currently no mobile application designed for radiotherapy purposes available locally, we designed some wire-frames to illustrate the various features of a radiotherapy application. Among the app's features, 'alert my doctor when experiencing severe symptoms' and 'appointment management' were identified as the most useful. On the contrary, the videoconferencing feature received the lowest rating despite the fact that participant opinions on this aspect varied widely. Likewise, the inclination to report side effects varied significantly among participants. Numerous studies have shown that while patients might display initial interest in utilising an app, their engagement tends to diminish over time as their health improves and the need to use the app wanes [14,20,21]. These findings underscore the necessity of creating an adaptable application that caters to the unique needs of each patient while also emphasising the importance of fostering patient engagement in the app's design and functionality [18]. Most respondents preferred to be contacted via phone in case the doctor noted that they were experiencing severe side effects from the reports provided. This finding underscores the importance of maintaining human communication channels alongside technological solutions to ensure optimal patient care and response during critical situations.

Another notable discovery was that not all patients expressed willingness to share their data for research purposes. Similarly to the study of Vo et al. [18], the patients in this study also reported that they had some reservations about the security of this app. Therefore, the app design should also address these security concerns to safeguard patient data and thus increase the level of trust and, ultimately, user engagement.

The study has some limitations that have to be acknowledged. The short data collection period available for this study and the low response rate limited the sample size of our study and ultimately limited the generalisability of our research findings. Furthermore, the small sample size may have led to the exclusion of viewpoints from patients, particularly those with lower levels of education who might have been less inclined to participate in the questionnaire. Lastly, despite the provision of print screens illustrating the technology's appearance, it is important to note the patients did not have first-hand experience with the technology. Consequently, further research is necessary to evaluate the service's feasibility following the deployment of the mobile app. As the digital divide among different age groups is expected to continue to decrease in the coming years, further research is required to assess the long-term impact of this application.

https://doi.org/10.1017/S1460396923000407 Published online by Cambridge University Press

Conclusion

Overall, the findings indicate that most of the patients included in this study have access to mobile technology and are willing to use the mobile app as an additional supportive care tool. Nonetheless, the diversity of patient perspectives regarding the technology underscores the importance of developing a mobile app that can be easily tailored to meet individual patient needs.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/S1460396923000407.

Acknowledgements. The authors would like to thank all the professionals who gave their invaluable support during data collection, without whom this study could not have been completed. Gratitude goes to Prof. Liberato Camilleri for his guidance in the statistical analysis of data. The authors also would like to thank Mr. Vimalesan Murugesan, Ms. Clarissa Borg and Ms. Claire Farrugia for providing print screens of their prototype radiotherapy application and for reviewing the questionnaire.

Author contributions. Ms. Maria Stella Sammut conceived the study protocol collected the data, analysed the data and wrote the manuscript.

Dr. Susan Mercieca supervised the project and edited the final manuscript.

Financial support. This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

Competing interests. The authors have no conflict of interest to declare.

References

[1] Berman R, Laird BJA, Minton O, Monnery D, Ahamed A, Boland E, et al. The rise of supportive oncology: a revolution in cancer care. Clin Oncol 2023; 35: 213–215. https://doi.org/10.1016/j.clon.2023.01.015.

[2] Paterson C, Jensen BT, Jensen JB, Nabi G. Unmet informational and supportive care needs of patients with muscle invasive bladder cancer: a systematic review of the evidence. Eur J Oncol Nurs 2018; 35: 92–101. https://doi.org/10.1016/J.EJON.2018.05.006.

[3] Hart NH, Crawford-Williams F, Crichton M, Yee J, Smith TJ, Koczwara B, et al. Unmet supportive care needs of people with advanced cancer and their caregivers: a systematic scoping review. Crit Rev Oncol Hematol 2022; 176: 103728. https://doi.org/10.1016/J.CRITREVONC.2022.103728.

[4] Aljedaani B, Babar MA. Challenges with developing secure mobile health applications: systematic review. JMIR Mhealth Uhealth 2021; 9 (6): E15654. https://doi.org/10.2196/15654.

[5] Piras A, Venuti V, D'aviero A, Cusumano D, Pergolizzi S, Daidone A, et al. Covid-19 and radiotherapy: a systematic review after 2 years of pandemic. Clin Transl Imaging 2022; 10: 611–630. https://doi.org/10.1007/s40336-022-00513-9.

[6] Varian. Care management 2023. https://www.varian.com/products/software/care-management (accessed August 10, 2023).

[7] Elekta. Elekta Kaiku Pioneering the personalization of cancer care 2023. https://www.elekta.com/products/life-sciences/elekta-kaiku/ (accessed August 10, 2023).

[8] Janssen S, Shafie R A El, Ruder AM, Buergy D, Scafa D, et al. Mobile applications in radiation oncology-current choices and future potentials. Strahlenther Onko 2023; 199: 337–349. https://doi.org/10.1007/s00066-023-02048-y.

[9] Holch P, Absolom KL, Henry AM, Walker K, Gibson A, Hudson E, et al. Online symptom monitoring during pelvic radiation therapy: randomized pilot trial of the eRAPID intervention. Int J Radiat Oncol Biol Phys 2023; 115: 664–676. https://doi.org/10.1016/j.ijrobp.2022.09.078.

[10] Sundberg K, Wengström Y, Blomberg K, Hälleberg-Nyman M, Frank C, Langius-Eklöf A. Early detection and management of symptoms using an interactive smartphone application (Interaktor) during radiotherapy for prostate cancer. Support Care Cancer 2017; 25: 2195–2204. https://doi.org/10.1007/S00520-017-3625-8.

[11] El Shafie RA, Weber D, Bougatf N, Sprave T, Oetzel D, Huber PE, et al. Supportive care in radiotherapy based on a mobile app: prospective multicenter survey. JMIR Mhealth Uhealth 2018; 6: e10916. https://doi.org/10.2196/10916.

[12] Hauth F, Bizu V, App R, Lautenbacher H, Tenev A, Bitzer M, et al. Electronic patient-reported outcome measures in radiation oncology: initial experience after workflow implementation. JMIR MHealth UHealth 2019; 7. https://doi.org/10.2196/12345.

[13] Frutos E, Descalzo J, Colussi G, Rapisarda R, Plazzotta F, Luna D. Exploring the digital divide as a barrier to use of a personal health record in the elderly. Stud Health Technol Inform 2022; 294: 545–549. https://doi.org/10.3233/SHTI220518.

[14] Lau EY, Mitchell MS, Faulkner G. Long-term usage of a commercial mHealth app: a "multiple-lives" perspective. Front Public Health 2022; 10: 914433. https://doi.org/10.3389/FPUBH.2022.914433/BIBTEX.

[15] Zamanzadeh V, Ghahramanian A, Rassouli M, Abbaszadeh A, Alavi-Majd H, Nikanfar A-R. Design and implementation content validity study: development of an instrument for measuring patient-centered communication. J Caring Sci 2015; 4: 165–178. https://doi.org/10.15171/jcs.2015.017.

[16] Beneito-Montagut R, Rosales A, Fernández-Ardèvol M. Emerging digital inequalities: a comparative study of older adults' smartphone use. Soc Media + Soc 2022; 8. https://doi.org/10.1177/20563051221138756.

[17] Vulpe S, Crăciun A. Silver surfers from a European perspective: technology communication usage among European seniors. Eur J Ageing 2020; 17: 125–134. https://doi.org/10.1007/S10433-019-00520-2/METRICS.

[18] Vo V, Auroy L, Sarradon-Eck A. Patients' perceptions of mHealth apps: meta-ethnographic review of qualitative studies. JMIR Mhealth Uhealth 2019; 7 (7): E13817. https://doi.org/10.2196/13817.

[19] Ownby RL, Acevedo A, Waldrop-Valverde D, Woodruff NH. Enhancing the impact of mobile health literacy interventions to reduce health disparities. Q Rev Distance Educ 2019; 20: 34.

[20] Gebert P, Schindel D, Frick J, Schenk L, Grittner U. Characteristics and patient-reported outcomes associated with dropout in severely affected oncological patients: an exploratory study. BMC Med Res Methodol 2021; 21: 1–11. https://doi.org/10.1186/S12874-021-01259-0/FIGURES/4.

[21] Amagai S, Pila S, Kaat AJ, Nowinski CJ, Gershon RC. Challenges in participant engagement and retention using mobile health apps: literature review. J Med Internet Res 2022; 24. https://doi.org/10.2196/35120.