

Original Article

Development and Feasibility Evaluation of Smart Cancer Care 2.0 Based on Patient-Reported Outcomes for Post-Discharge Management of Patients with Cancer

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Running Title: Development of Smart Cancer Care 2.0

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This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process which may lead to differences between this version and the Version of Record. Please cite this article as an 'Accepted Article', [doi:10.4143/crt.2024.003](https://doi.org/10.4143/crt.2024.003)

Abstract

Purpose

A “Smart Cancer Care” platform that integrates patient-reported outcomes (PROs) with management has been established in Korea. This study focused on improving health behaviors and connecting patients to welfare services by introducing and assessing the feasibility of “Smart Cancer Care 2.0,” an enhanced version designed for monitoring complications post-cancer treatment.

Materials and Methods

Smart Cancer Care 2.0 was developed by conducting a literature review and consulting with expert panels to identify symptoms or variables requiring monitoring and management guidelines based on the treatment type. Qualitative and quantitative surveys were conducted to assess the feasibility of the app and web system based on the experiences of patients with cancer and healthcare workers.

Results

A total of 81 symptoms or variables (chemotherapy-, surgery-, radiotherapy-, rehabilitation-, and health management-related) were selected for management in Smart Cancer Care 2.0. PROs for these symptoms were basically categorized into three severity grades: (1) preventive management, (2) self-treatment, and (3) consultation with a healthcare worker or visit to a healthcare institution. The overall mean scores in the feasibility evaluation by patients and healthcare workers were 3.83 and 3.90 points, respectively, indicating high usefulness.

Conclusion

Smart Cancer Care 2.0 leverages the existing ICT-based platform, Smart Cancer Care, and further includes health behaviors and welfare services. Smart Cancer Care 2.0 may play a crucial role in establishing a comprehensive post-discharge management system for patients

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with cancer as it provides suitable interventions based on patients' responses and allows the regularly collected PROs to be easily viewed for streamlined care.

Keywords

Mobile applications, Patient reported outcome measures, Drug-related side effects and adverse reactions, Patient discharge

Accepted Article

Introduction

In recent years, diverse cancer treatment methods have increased, and further efforts are being made to explore new approaches [1-3]. These endeavors have contributed to a consistent increase in the survival rate among patients with cancer, leading to longer durations of living with cancer [4,5]. Consequently, the focus has shifted from reducing mortality in patients with cancer to preserving and enhancing health-related quality of life [6,7]. Paradoxically, the side effects of various treatments intended to improve survival can negatively impact the health-related quality of life in patients with cancer [8]. Therefore, establishing a healthcare system capable of addressing the unmet needs of patients with cancer, including the side effects experienced during treatment, is crucial [9].

Effectively managing the diverse treatment side effects and unmet needs of patients with cancer requires personalized interventions with real-time monitoring, even after discharge. Several studies have attempted to achieve this by regularly collecting patient-reported outcomes (PROs) using post-discharge standardized questionnaires [10-15]. Symptom management through these PROs has proven effective in alleviating symptoms, enhancing health-related quality of life, and preventing unexpected hospitalization events. However, well-planned and high-quality research is still needed [8,16]. Additionally, previous research has predominantly focused on symptom management, and a considerable gap exists in understanding the development of a more comprehensive post-discharge management system for patients with cancer, including improvements in health behaviors and connections to welfare services [17,18].

In Korea, the “Smart Cancer Care” platform was established for the management of chemotherapy side effects [19]. This platform endeavors to implement connected health through bidirectional communication, utilizing information and communication technologies

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(ICT) to systematically collect PROs from patients undergoing chemotherapy and provide interventions tailored to their responses [11,20]. However, a limitation of the existing Smart Cancer Care platform is its applicability primarily to patients undergoing chemotherapy, with challenges in extending its use to patients undergoing surgery or radiotherapy. Efforts have been made to enhance the system to address the improvement of health behaviors and unmet welfare needs for patients with cancer.

This study aimed to introduce an enhanced version of Smart Cancer Care that allows for a more comprehensive post-discharge management approach for patients with cancer. Specifically, we presented the detailed composition of Smart Cancer Care 2.0, which enables the monitoring of side effects from various treatment modalities, including surgery, radiotherapy, and chemotherapy. Moreover, it includes functions for improving health behaviors and linking patients with cancer to welfare services. The feasibility of Smart Cancer Care 2.0 was also evaluated through a pilot test involving patients with colon and breast cancer.

Materials and Methods

1. Setting

This study introduced the development process and the composition of Smart Cancer Care 2.0, which will be used in post-discharge management systems for patients with cancer. We also conducted a pilot test of Smart Cancer Care 2.0 at a single regional cancer center in Korea [21] and evaluated its feasibility.

2. Cancer and classification of treatment types

Smart Cancer Care 2.0 was designed to promote the expansion of cancer management systems and allow the administrator to directly set the types of cancer that will be monitored,

unlike the previous Smart Cancer Care, which was targeted at common cancer types in Korea, including stomach, colon, lung, and breast cancers. Smart Cancer Care 2.0 broadly distinguishes between the following treatment types: chemotherapy (also in the previous version), surgery, radiotherapy, rehabilitation therapy, and health management, and provides flexibility in the classification of treatment types, allowing the user to add treatment modalities as required by the patient.

3. Monitoring symptoms (or variables) and development of management guidelines

Symptoms (or variables) that require monitoring and management guidelines were developed for Smart Cancer Care 2.0, depending on the treatment modality. For chemotherapy, the side effects and management guidelines from the previous version were retained [19], whereas for surgery, radiotherapy, and rehabilitation therapy, we reviewed guidelines from related academic societies to select the symptoms to be monitored during treatment and develop the corresponding management guidelines. Thereafter, two experts from related academic societies reviewed the suitability of the monitored symptoms and management guidelines.

For health management, we selected variables and made a draft of guidelines with reference to health management guidelines for survivors of cancer from the National Comprehensive Cancer Network, guidelines provided by the National Cancer Information Center and related academic societies, as well as information provided by major healthcare institutions. A further revision was performed by one attending physician of preventive medicine from the Korean Society for Preventive Medicine and one professor of nursing to set the final health management variables and guidelines to be used in Smart Cancer Care 2.0.

These symptoms or variables were basically categorized into three severity grades: preventive management (grade 1), self-treatment (grade 2), and consultation with a healthcare

worker or visit to a healthcare institution (grade 3) with reference to previous studies [20, 22]. However, in the case of variables related to health management, the guidelines were developed by classifying PROs into those require additional consultation or action and those that do not.

4. Platform development and feasibility evaluation

We enhanced the existing Smart Cancer Care platform, which was developed to manage the side effects of chemotherapy, to create the Smart Cancer Care 2.0 platform for post-discharge management of patients with cancer. Smart Cancer Care 2.0 is divided into an app and web system for patients, which allows them to evaluate their symptoms (or variables) that need to be managed depending on their cancer type and treatment details. It also provides them with management guidelines based on the results and a dashboard for healthcare workers to help them design interventions by checking results input by the patient in real-time.

To evaluate the feasibility of both the app and web system for patients and the dashboard for healthcare workers, we conducted a pilot test of Smart Cancer Care 2.0 with patients with cancer and cancer treatment-related healthcare workers and analyzed their experiences. After allowing patients and healthcare workers to use Smart Cancer Care 2.0 for approximately 3–4 weeks (4 weeks for patients, 1 week for healthcare workers), the feasibility was evaluated from cognitive, psychological, compositional, and social perspectives (12 questions in total), using the same evaluation domains and items as in a previous study [19].

Each item of domain was evaluated on a 5-point scale (0 points: Strongly disagree, 1 point: Disagree, 2 points: Not sure, 3 points: Agree, 4 points: Strongly agree). The higher the score, the higher the feasibility in terms of each item of domain. However, the three negative questions (ex: “The overall content of the program was difficult to understand”) were reverse coded and analyzed. An independent sample t-test was performed on each item that could be

compared to determine whether there was a statistically significant difference. In addition, open questions were used to investigate participants' qualitative opinions of Smart Cancer Care 2.0.

Results

1. Review of monitored symptoms and management guidelines

A total of 81 symptoms (or variables) were selected to be managed in Smart Cancer Care 2.0 (S1 Table). Table 1 presents representative questions for each treatment type. Specifically, these comprised 31 major side effects of chemotherapy selected for Smart Cancer Care 1.0, 22 symptoms related to surgery (7 for breast cancer and 15 for colon cancer), 5 symptoms related to radiotherapy (2 for breast cancer and 3 for colon cancer), 11 symptoms related to rehabilitation, and 12 variables related to health management. The management guidelines for each symptom (or variable) are shown in supplement (S2 Table).

2. App and web system for patients

The system was designed to allow patients to install and use the service as an application. However, to account for patients with difficulties installing an app, such as older patients, a web-based version was implemented. The app download and registration functions were similar to the previous version of Smart Cancer Care. The previous version focused on the management of side effects in patients who underwent chemotherapy at a single healthcare institution, whereas Smart Cancer Care 2.0 targets comprehensive post-discharge management of diverse patients with cancer within the community, enabling multiple healthcare institutions and physicians to select the appropriate options for the patient's current treatment circumstances (Fig. 1).

Patients are provided with a list of symptoms (or variables) that need to be evaluated

depending on the type of cancer and treatment, and they undergo an assessment for the presence and severity of each symptom (Fig. 2). Depending on the results of the symptom evaluation, patients are provided with guidelines for managing their symptoms, and these guidelines are divided into up to 3 grades: preventive management (grade 1), self-treatment (grade 2), consultation with a healthcare worker or visit to a healthcare institution (grade 3). Similar to the previous Smart Cancer Care version, overall diagnostic outcomes can be examined on a single screen once an assessment of all symptoms has been completed. The symptoms encyclopedia has also been expanded to include not only chemotherapy but also surgery, radiotherapy, and health management domains, and additions have also been made to the frequently asked questions.

3. Dashboard for healthcare workers

Similar to the previous version of Smart Cancer Care, the dashboard in Smart Cancer Care 2.0 allows the administrator or authorized healthcare worker to retrospectively view the symptom (or variable) responses input by the patient according to the date of assessment. However, unlike the previous version, the dashboard is loaded onto the electronic medical records of the healthcare institution to improve its accessibility for healthcare workers. Basically, the healthcare worker can click the “PRO” icon to immediately check the dashboard on the list of inpatients or outpatients (Fig. 3).

The system administrator can adjust the permissions of the healthcare institution and healthcare workers. In particular, the administrator can change the symptoms (or variables) that need to be monitored depending on the type of cancer and treatment circumstances. Moreover, in metadata management mode, the administrator can also edit the guidelines themselves for each cancer type, treatment method and class, or patient responses, thereby improving the adaptability of Smart Cancer Care 2.0 (Fig. 4).

4. Feasibility evaluation

A total of 81 patients with cancer and 21 cancer-related healthcare workers participated in the feasibility evaluation for Smart Cancer Care 2.0 (Table 2). The sociodemographic characteristics of the participants are shown in supplement (S3 Table and S4 Table). The overall mean (standard deviation) scores in the feasibility evaluation by patients and healthcare workers were 3.83 (0.48) and 3.90 (0.29) points, respectively, showing a statistically significant difference (p-value: 0.016) (Table 1).

The score provided by the patients was highest in response to the statement “I would feel at ease if my side effects were managed using the program” (4.30 points), followed by “I hope this program will be widely used” (4.21 points), and “The content of the program was overall difficult to understand (reverse-coded)” (4.19 points). The score provided by the healthcare workers was highest to the statement “I hope this program will be widely used” (4.62 points), followed by “the program will help with patient care” (4.43 points), and “I would feel at ease if patients' side effects were managed using the program” (4.43 points). Meanwhile, statistically significant differences were confirmed in two items of the social domain. For example, in the item “I hope the program will be widely used,” the score of healthcare workers (4.62 points) was statistically significantly higher than that of patients (4.21 points).

In Table 3, we summarized the experiences of patients and healthcare workers using Smart Cancer Care 2.0 based on open questions. Several patients expressed reduced anxiety as they were able to use Smart Cancer Care 2.0 to check and convey their situation. Patients also learned directly and indirectly about the symptoms and variables they need to manage themselves and methods of coping with these symptoms. Therefore, the use of Smart Cancer Care 2.0 is expected to improve patients' interest in health and their self-efficacy for health

management. Patients suggested core improvements regarding the screen and the questions. We anticipate that Smart Cancer Care 2.0 will be able to help healthcare workers form rapport with their patients while also having a positive effect on reducing their workload. However, since some healthcare workers are still not familiar with Smart Cancer Care 2.0, gaining experience with its use will be required. From the perspective of healthcare workers, composing the dashboard in a way that makes it easy to check relevant information is still an important task, and they also emphasized the need to revise the system to improve patients' understanding by adding photographs or videos. Moreover, they mentioned preparing additional strategies targeted towards older patients.

Discussion

In this study, we developed Smart Cancer Care 2.0 by building upon the existing ICT-based Smart Cancer Care platform designed for managing chemotherapy side effects. The enhanced version manages side effects resulting from comprehensive health management, including surgery, radiotherapy, rehabilitation, health behaviors, and welfare services. The platform comprises an app and web system for patients, systematically collecting PROs related to patients with cancer symptoms and unmet needs. It offers tailored interventions based on patients' responses. Additionally, it features a dashboard for healthcare workers to regularly examine collected PROs for informed treatment decisions. We anticipate that Smart Cancer Care 2.0 will play a pivotal role in establishing comprehensive post-discharge management systems for patients with cancer. In our feasibility evaluation, while identifying areas for improvement from the perspectives of patients and healthcare workers, we found Smart Cancer Care 2.0 to be generally useful across cognitive, psychological, compositional, and social dimensions.

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To date, only a few comprehensive systems utilizing PROs for the post-discharge management of patients with cancer exist. Previous research has predominantly focused on managing the side effects of chemotherapy [16,23]. Although postoperative symptom monitoring has been attempted [20,22,24], systems addressing the side effects of radiotherapy, rehabilitation therapy, and other aspects of health management remain lacking. As cancer treatment becomes more complex and patients present various unmet needs, there is a growing need for comprehensive management to enhance health-related quality of life of patients with cancer [8,9]. The composition of Smart Cancer Care 2.0 presented in this study is expected to contribute to the development of comprehensive management systems for patients with cancer in the realms of public healthcare, medicine, and welfare, not only in Korea but also internationally.

While comprehensive management systems for patients with cancer are crucial, considering limited healthcare resources, reaching a consensus on prioritizing diverse symptoms and unmet needs for monitoring and improvement is essential. In Smart Cancer Care 2.0, 81 symptoms (and variables) were selected for monitoring in patients with breast and colon cancer. As the system gains usage experience, the characteristics of collected PROs need analysis, including adjustments to the number of monitored symptoms (and variables) and setting monitoring intervals based on treatment types, leading to program refinements. Efficient interventions based on limited resources will be determined by investigating the severity distribution of symptoms.

This study's value lies in verifying the high feasibility of Smart Cancer Care 2.0. Similar to the feasibility evaluation of the previous Smart Cancer Care version [19], patients with cancer and healthcare workers highly rated the usability of Smart Cancer Care 2.0 across cognitive, psychological, compositional, and social domains. The previous version aimed to

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alleviate chemotherapy-related anxiety [19], whereas Smart Cancer Care 2.0, addressing all aspects of cancer treatment, is expected to enhance patients' learning and self-efficacy. This could facilitate the adoption of shared decision-making in the broader field of cancer treatment [25,26]. From healthcare workers' perspectives, Smart Cancer Care 2.0 is anticipated to aid in forming a rapport with patients and providing personalized treatment, as evidenced by the feasibility evaluation score, which is higher than that of patients. The study demonstrates the high applicability of Smart Cancer Care 2.0 in clinical settings [27].

Nevertheless, further efforts are required to enhance the usability of Smart Cancer Care 2.0. Although the previous version's limitation regarding linkage to electronic medical records has been addressed in Smart Cancer Care 2.0, room for improvement still exists in the composition of the dashboard screen to alleviate the burden on healthcare workers. Additionally, for better communication of treatment-related information to patients, enhancing the system to allow the uploading of photographs or videos is essential. Considering the gradual increase in the average age of patients with cancer, designing ICT-based platforms that are older adult-friendly and developing effective educational interventions tailored for older patients with cancer are vital [28].

Gaining experience with the use of Smart Cancer Care 2.0 is crucial. Therefore, integrating post-discharge management projects employing Smart Cancer Care 2.0 with other contemporary healthcare policies in Korea, such as the establishment of a regionally complete public healthcare system and the designation and operation of accountable care hospitals, is crucial [29]. Despite the relatively low relevance index for cancer in Korea [30], post-discharge management of patients with cancer is expected to not only enhance patients' treatment experiences but also improve the relevance index by addressing various challenges faced by patients within the community during treatment. The community linkage of discharged patients

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is a mandatory aspect of the accountable-care hospitals' project, making it worthwhile to prioritize patients with cancer within this system.

Although Smart Cancer Care 2.0 was designed to be applicable to all types of cancer, it is currently configured only for breast and colon cancer. Future efforts should focus on developing and applying relevant details, such as monitored symptoms and guidelines, for other prevalent cancers in Korea, including lung, stomach, and thyroid cancer. Although Smart Cancer Care 2.0 was designed for application in multi-center network projects, it has thus far been employed solely in a single healthcare institution. Further, expanding experiences with the use of Smart Cancer Care 2.0 through collaboration with various healthcare institutions, including clinics and pharmacies, is crucial.

In conclusion, Smart Cancer Care 2.0 can play a central role in post-discharge management systems for patients with cancer. Future endeavors should involve extensive testing of a comprehensive post-discharge management program for patients with cancer, utilizing Smart Cancer Care 2.0 in diverse communities, and evaluating its effects.

Ethical statement

The study was approved by the Institutional Review Board of Ulsan University Hospital (Project number: 2021-05-042).

Author Contributions

Conceived and designed the analysis: Kwon JA, Yang S, Koh SJ, Noh YJ, Kang DY, Yang SB, Kwon EJ, Seo JW, Kim JS, Ock M.

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Conflicts of Interest

Conflict of interest relevant to this article was not reported.

Acknowledgments

This study was supported by a grant from the National R&D Program for Cancer Control, Ministry of Health & Welfare, Republic of Korea (HA21C0107).

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Table 1. Representative questions for each of the monitored symptoms (or variables)

Treatment type ^{a)}	Disease type	Symptom category	Questions for monitoring
Chemotherapy	-	Oral/Pharyngeal mucositis	Stage 1: Do you have mouth ulcers? 1. Yes 2. No Stage 2: Do you have pain due to mouth ulcers? 1. Yes (G2 or G3) 2. No (G1) Stage 3: How much less are you eating due to mouth ulcers? 1. I can't eat at all (G3) 2. I am eating less (G2) 3. No change in the amount I eat (G1)
Surgery	Breast cancer	Hematoma	Stage 1: Do you have bruises at the site of surgery? 1. Yes (G1, G2 or G3) 2. No Stage 2: Do you have a swelling sensation at the site of surgery? 1. Yes (G2 or G3) 2. No (G1) Stage 3: Is the site of surgery gradually swelling up? 1. It's a little swollen, but I have no sense that it is gradually swelling up. (G2) 2. There is bruising; I can feel it gradually swelling up, and I have pain. (G3)
Surgery	Colon cancer	Diarrhea (Loose stools)	Stage 1: Do you have loose stools or diarrhea 3–5 times per day? 1. Yes 2. No Stage 2: Do you have difficulties in daily living due to frequent diarrhea? 1. Yes (G2 or G3) 2. No (G1)

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			<p>Stage 3: Do you have persistent diarrhea or loose stools more than 7 times per day accompanied by a fever of over 38 °C?</p> <ol style="list-style-type: none"> 1. Yes (G3) 2. No (G2)
Radiotherapy	Breast cancer	Radiotherapy dermatitis	<p>Stage 1: Do you have skin redness or flaking skin without secretions at the treatment site?</p> <ol style="list-style-type: none"> 1. Yes (G1, G2 or G3) 2. No <p>Stage 2: How much itchiness have you experienced alongside skin reddening at the treatment site?</p> <ol style="list-style-type: none"> 1. None (G1) 2. A little (G1, G2 or G3) 3. Unbearable severe itching (G1) G1) <p>Stage 3: How much skin shedding with secretions have you experienced?</p> <ol style="list-style-type: none"> 1. No skin shedding (G1) 2. A little skin shedding (G2) 3. A lot of skin shedding (G3)
Radiotherapy	Colon cancer	Rectal hemorrhage	<p>Stage 1: Have you observed red blood from your anus?</p> <ol style="list-style-type: none"> 1. Yes 2. No <p>Stage 2: Does red blood continue to come out of your anus?</p> <ol style="list-style-type: none"> 1. No (G1) 2. Rarely (G2) 3. Yes (G3)
Rehabilitation therapy	Breast cancer	Shoulder pain	<p>Stage 1: Do you have pain?</p> <ol style="list-style-type: none"> 1. Yes (G1, G2 or G3) 2. No <p>Stage 2: How severe is your pain?</p> <ol style="list-style-type: none"> 1. I have mild pain (NRS 1–3), but it does not cause major problems in daily living (G1)

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			2. I have moderate pain (NRS 4–6) that sometimes is difficult to bear during daily living (G2)
			3. I have severe pain (NRS 7–10) that makes me extremely uncomfortable in daily living (G3)
Health management	All cancer	Immunizations and Infections	Have you been vaccinated against influenza this year? 1. Yes 2. No 3. Not sure Are you aware of the latest information about the vaccines you need? 1. Yes 2. No 3. Not sure Considered positive if the patient responds “No” or “Not sure” to either of the two questions

^{a)}Representative symptoms and questions for monitoring for each treatment type. G1, Grade 1; G2, Grade 2; G3, Grade 3; NRS, Numerical rating scale.

Table 2. Results of feasibility evaluation by patients and healthcare workers

Evaluation domain	Patients (n = 81)		Healthcare workers (n = 21)		p-value ^{b)}
	Statement	Mean ± S.D. ^{a)} (possible range: 1–5)	Statement	Mean ± S.D. ^{a)} (possible range: 1–5)	
Cognitive	I was able to understand the uses of the program	4.10 ± 0.68	I was able to understand the uses of the program	4.24 ± 0.54	0.388
	The overall content of the program was difficult to understand (reverse-coded)	4.19 ± 0.88	The overall content of the program was difficult to understand (reverse-coded)	3.90 ± 0.89	0.198
	Overall, the program was easy to use	4.16 ± 0.93	Overall, the program was easy to use	4.14 ± 0.65	0.935
Psychological	It was uncomfortable to input my treatment situation to the program (reverse-coded)	3.95 ± 0.99	It was uncomfortable to use the program to check patient-related information (reverse-coded)	3.76 ± 0.89	0.428
	I would feel at ease if my side effects were managed using the program	4.30 ± 0.77	I would feel at ease if patients' side effects were managed using the program	4.43 ± 0.81	0.487
	I want to recommend the program to other patients with cancer I know	4.01 ± 0.93	I want to recommend the program to other healthcare workers I know	4.24 ± 0.77	0.308
Compositional	The information input to the program reflects my treatment situation accurately	3.79 ± 0.96	The patient information that can be obtained through the program is appropriate	3.95 ± 0.67	0.467

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	I need to respond to too many questions in the program's questionnaires (reverse-coded)	3.75±0.99	Checking patients' symptoms through the program will help provide appropriate treatment to patients	4.29 ± 0.56	Incomparable
	I need help from someone else to use the program	2.00 ± 1.15	Additional functions are needed for the use of the program	3.14 ± 0.85	Incomparable
Social	Using a side effect management program will reduce hospital visits	3.51 ± 0.90	The program will reduce the overall burden of side effect management for patients	4.19 ± 0.60	Incomparable
	The program will help when I have a consultation with healthcare workers	4.05 ± 0.72	The program will help with patient care	4.43 ± 0.51	0.026
	I hope the program will be widely used	4.21 ± 0.68	I hope the program will be widely used	4.62 ± 0.50	0.012
Total	-	3.83 ± 0.48	-	3.90 ± 0.29	0.016

^{a)}Higher scores indicate better usability in each domain (5-point Likert scale), ^{b)}Independent samples t-test for comparable items.

Table 3. Patients and healthcare workers' positive and negative experiences of using Smart Cancer Care 2.0

	Patients	Healthcare workers
Positive	<ul style="list-style-type: none"> • I feel less anxious because I have a portal where I can check and convey my situation. • I was able to learn about representative side effects, how to cope with them, and cautions. • I became more interested in side effects that I am not suffering from now, but could suffer from in the future, and I started thinking more about my health. • The program is simple and the categories are well organized. • Although it was difficult at first, the program became familiar after having it explained and using it a few times. 	<ul style="list-style-type: none"> • This program will definitely help patient care, because it enables to check past symptoms in patients who were not very talkative. • It is difficult to ask in detail about patients' symptoms in a busy outpatient setting, and it helps patient care if symptoms can be checked in advance like this. • By checking the patient's self-diagnostic log and initiating conversation, I was able to obtain the patient's emotional support. • Patients are often curious about their symptoms, and the symptom encyclopedia provided in this program will help responding to their questions.
Negative	<ul style="list-style-type: none"> • The program was not especially helpful because I have not experienced many side effects of treatment. • The lack of an automatic login function was uncomfortable. • I could solve my problems because there were no questions relating to my symptoms. It would be good if there were a function to add symptoms or variables; I think the question composition will need to be matched better to the patients. • It would be good to see all the symptoms that need to be checked at a glance. • Although it was overall easy to understand, some technical terminology was difficult. • It would be good if there was an explanation about the reasons behind each variable. 	<ul style="list-style-type: none"> • I think I still need to get a little bit more experience getting familiar with using this program for work. • The composition of the dashboard is okay, but it is uncomfortable that we have to press on the PRO icon to see the dashboard. • It would be good if we could see details about the severity scores of symptoms within the dashboard. • It would be good if we could go back a stage and edit information if we made the wrong input. • It would be easier to explain about symptoms if photographs or videos could be uploaded. • I think this will still be difficult to use for older patients, and a nursing consultation will be necessary.

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The screenshot displays three sequential steps in a mobile application interface for selecting cancer type, healthcare institution, and healthcare worker.

- Step 1: 진단명(암종)선택 (Cancer Type Selection)**
 - Header: < 회원가입 ≡
 - Text: 확진 받으신 진단명을 선택해 주세요.
 - Dropdown menu: 위암
 - Button: 다음으로 →
- Step 2: 내원병원 선택 (Healthcare Institution Selection)**
 - Header: < 회원가입 ≡
 - Text: 내원병원
 - Dropdown menu: 울산대학교병원
 - Button: 다음으로 →
- Step 3: 담당의 선택 (Healthcare Worker Selection)**
 - Header: < 회원가입 ≡
 - List of workers:
 - 홍씨네 교수님
 - 김씨네 교수님
 - Button: 회원가입 완료

At the bottom, a navigation bar contains icons for Home, Self-Diagnosis, Calendar, and Symptom Check, repeated for each step.

Fig. 1. Selection of cancer type, healthcare institution, and healthcare worker in Smart Cancer Care 2.0.



Fig. 2. List of symptoms (or variables) for self-diagnosis and presentation of the results.

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나이	시간	진단명	보험유형	초/재	접수	AMC	입원	알림	서명	기록	모바일	임상부	PRO
F/52세	09:25	Malignant neoplasm of breast unspecified, left	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/49세	09:30	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/59세	09:33	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/51세	09:35	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/76세	09:40	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/68세	09:45	Malignant neoplasm of upper-inner quadrant of ...	급여1종	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/71세	09:45	Secondary malignant neoplasm of bone and bone...	차상위회	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/65세	09:50	Malignant neoplasm of upper-outer quadrant of ...	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/45세	09:55	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/54세	10:01	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/50세	10:05	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/53세	10:07	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/51세	10:10	Chemotherapy session for neoplasm	공단	재진	당일	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/63세	10:13	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/77세	10:18	Malignant neoplasm of breast unspecified, unsp...	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/64세	10:20	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/65세	10:23	Chemotherapy session for neoplasm	공단	재진	URC	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/42세	10:28	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/51세	10:33	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/64세	10:38	Secondary malignant neoplasm of pleura	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/57세	10:43	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/38세	10:48	Malignant neoplasm of breast unspecified, right	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/57세	10:53	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input checked="" type="checkbox"/>
F/45세	10:58	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/54세	11:03	Malignant neoplasm of breast unspecified, right	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/68세	11:08	Malignant neoplasm of upper-outer quadrant of ...	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>
F/62세	11:13	Chemotherapy session for neoplasm	공단	재진	예약	<input type="checkbox"/>					완료	확정	<input type="checkbox"/>

Fig. 3. PRO icons in the outpatient list.

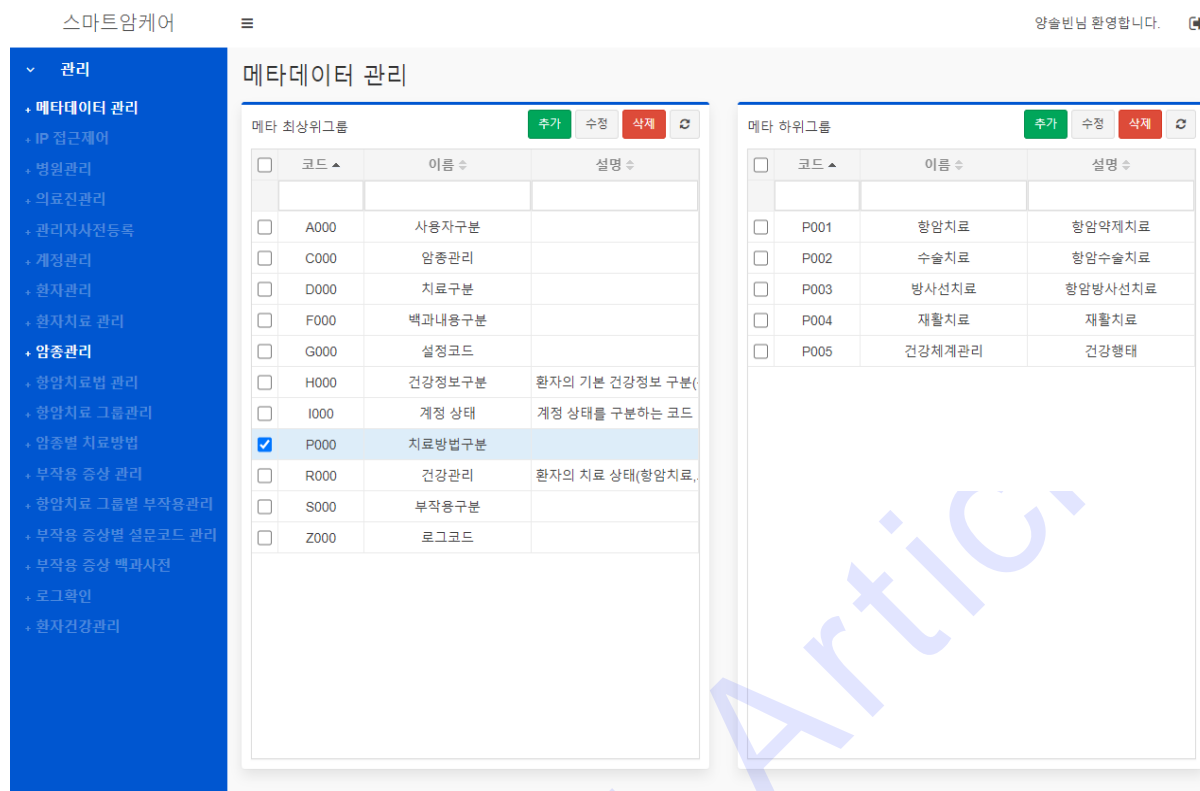


Fig. 4. Metadata management.