The impact of training chemotherapy safety standards with a smartphone application on the knowledge, attitude, and performance of nurses

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Abstract

Background: Nurses who play the leading role in caring for patients, especially nurses in the chemotherapy department who are constantly exposed to high-risk drugs and their side effects, should pay more attention to occupational safety. This study was performed to determine the effect of training chemotherapy safety standards using a smartphone application on nurses' knowledge, attitude, and practice.

Methods: The whole enumeration selected fifty oncology nurses from 3 hospitals affiliated with Lorestan University of Medical Sciences (western Iran). The study was conducted from June to November 2021. The training was done for four weeks with a smartphone application, including six main courses of familiarity with antineoplastic drugs, personal protective equipment, drug preparation, prescription and transfer, waste leakage, and elimination. The nurses' knowledge, attitude, and performance questionnaire were completed before, immediately, and one month after the intervention. Data analysis was performed using SPSS version 26, descriptive and inferential statistical tests of independent t-test, one-way analysis of variance, Spearman's rank correlation coefficient, repeated measures analysis of variance, and the Generalized Estimating Equation (GEE) model.

Results: Mean knowledge score of participants before, immediately, and one month after the intervention was (47.18 ± 8.19), (60.08 ± 3.82), and (61.88 ± 3.45), respectively. The mean attitude score of participants before, immediately, and one month after the intervention was (30.34 ± 3.94), (34.32 ± 3.25), and (34.98± 2.88), respectively, and the mean performance score of participants before, immediately, and one month after the intervention was (43.60 ±5.11), (51.78 ± 3.15) and (52.88 ± 3.06), respectively. The mean nurses' knowledge, attitude, and performance score increased significantly over time (P <0.001).

Conclusions: Teaching chemotherapy safety standards using the application improved oncology nurses' knowledge, attitude, and performance. Appropriate educational programs, especially new methods such as e-learning, are recommended for providing safety for nurses and methods of its promotion.

Background

Today, cancer is one of the leading health concerns of human societies [1]. The number of 19.3 million new cancer cases and approximately 10 million deaths were estimated worldwide in 2020; the incidence of cancer increased with the growth of the human development index for men and women from 104.3 and 128.0 per 100,000 people in countries with low index levels, and 335.3 and 267.6 per 100,000 people in countries with high index level, respectively. Also, the most common cancers worldwide were reported as breast, lung, colorectal, prostate, and stomach cancer, respectively [2]. The prevalence of cancer in Iran almost doubled between 2000 and 2016, and the crude cancer rate was 155 per 100,000 people of both sexes and all ages [1]. Chemotherapy is the most common treatment for many cancers [3]. However, anticancer drugs are also teratogenic, mutagenic, and carcinogenic agents for humans [4]. Oncology nurses, who play the most critical role in the care of cancer patients, have the most exposure to

antineoplastic drugs during the preparation, injection, transfer, storage, and elimination of waste [5, 6]. Exposure to these drugs may cause side effects such as primary DNA damage [7], increased risk of breast and rectal cancer [8], the presence of mutagenic agents in the urine [9], and adverse effects on the reproductive system [10], and skin disorders [11] for nurses. International organizations such as the National Institute for Occupational Safety and Health (NIOSH), the American Society of Hospital Pharmacists (ASHP), the Oncology Nursing Society (ONS), and the Occupational Safety and Health Administration (OSHA) recommend standard guidelines to prevent and minimize occupational accidents of health care providers [12, 13]. Despite the availability of these guidelines, many conducted studies report an inappropriate situation of observing safety standards by nurses in Egypt [13], Iran [14, 15], Iraq [16], and Cyprus [17], and show the need to implement the guidelines and training in this field in oncology units.

Non-compliance with safety proceedings when working with antineoplastic drugs can be due to nurses' defects in knowledge, attitude, and performance (KAP). A study by Nwagbo et al. (2017) showed that oncology nurses needed to improve their knowledge in implementing standard guidelines [5]. People's attitude can change their behavior and affect their safety culture directly or indirectly [18]. The third factor that indicates nurses' non-compliance with safety standards is their performance with antineoplastic drugs. Gamal et al. (2019) found that nurses had poor performance in this area and did not follow international standards properly [19]. In Zayed et al. (2019) study, two-thirds of nurses' knowledge about the safe use of antineoplastic drugs was reported to be satisfactory, but only 36.4% of nurses had an appropriate performance. It was recommended to have pre-employment and in-service continuing education programs based on international standards [13]. Koulounti et al. (2019) also pointed out the need to implement educational programs with new techniques and methods to update nurses to protect them from antineoplastic drug side effects [17].

Various strategies have been used to improve the safety of nurses in oncology wards. In a systematic review performed by Crickman & Finnell (2016), five methods were introduced to reduce antineoplastic drugs exposure, including the development of engineering controls, the use of Personal Protective Equipment (PPE), medical and environmental monitoring of common antineoplastic drugs, and risk assessment and training for health care providers using a comprehensive hazardous drugs (HDs) control program for improving the occupational safety of nurses [20].

Choosing the teaching method can be influenced by the existing facilities to achieve educational goals [21]. One of the most critical changes in education in the new age of information is the paradigm change from teacher-centered to inclusive education [22]. E-learning is overgrowing as a new method and an alternative to providing education in nursing [23]. Some of the advantages of the E-learning method compared to the traditional one include reducing the commuting costs of learners, no need for nurses to leave the place [24], and improving self-efficacy [25]. Due to the interference of face-to-face retraining with nurse's working hours or their leisure time, their lots of commitments, intensive shifts, and lack of motivation, using E-learning as an alternative or a complement method of traditional training can be a good approach for nurses' retraining; This method is better adapted to rapid changes of educational

needs of health centers [24, 26]. Mobile learning is an emerging form of educational technology that complements learning outcomes by creating conversations, sharing information and knowledge, and assisting colleagues and educators regardless of their geographical distance [27]. Mobile applications are one of the most advanced forms of technology used in learning methods [28].

Surveys show that many studies have been conducted in the field of chemotherapy safety standards, including the study of Alehashem and Baniasadi (2018) to evaluate the KAP of oncology nurses for the safe use of antineoplastic drugs in Iran [29], Asefa Et al. (2021) cross-sectional study in Ethiopia [30], and the interventional study of Mishra et al. (2021) [31]. Most of the reviewed studies are performed non-interventional or interventional with methods such as lecture [21], video [32], and PowerPoint [31]. However, there was no study teaching these standards through E-learning. Thus, the present study aimed to detect the effect of teaching chemotherapy safety standards using a smartphone application on the KAP of oncology nurses.

Methods

Design, setting, and sample

This semi-experimental one-group post-test-pretest study was performed on three hospitals affiliated with Lorestan University of Medical Sciences / (western Iran) from June to November 2021. We used the total population sampling method. The population was the whole oncology ward nurses (57 people), from which 50 people were selected as a sample.

The inclusion criteria were as follows; employment in the chemotherapy department, having at least a bachelor's degree, not participating in a similar research project, and access to a smartphone; two people who did not enter the study; and not having a smartphone. Also, in case of unwillingness to continue cooperating with the study, not attending the meeting about getting familiar with the application, and changing the nurse section of work, the samples were excluded from the study. Five people were excluded from transfer from the oncology ward to other sections.

Data collection

We used the following two questionnaires to collect data.

Demographic Information Questionnaire

The demographic information questionnaire consisted of 13 questions about age, sex, marital status, level of education, employment status, nurse position, nursing work experience, oncology department work experience, dealing with cytotoxic drugs work experience, membership in oncology association, most hours of work shifts, average working hours per week, and training workplace instructions.

Questionnaire to assess the KAP of nurses about oncology safety standards

This tool was designed by Alehashem and Baniasadi (2018). It has three components in the 5-point Likert spectrum (strongly agree = 5, agree = 4, neutral = 3, disagree = 2 and strongly disagree = 1), which is completed as a self-report. The first component includes 13 questions to assess knowledge about protocols and standards for the preparation, management, excretion, and storage of antineoplastic drugs. The second section consists of eight questions assessing the sample participants' attitudes toward the oncology nurse's work and their concerns and feelings. The final section contains 12 performance-related questions used to evaluate participants' activities in the preparation, management, excretion, and storage of antineoplastic drugs. The mean scores were calculated for three sections of KAP, and the higher mean score indicated more agreement. The level of KAP was evaluated as the cut-off point using the mean score. This score was considered as 36 for knowledge with a range of 12-60, 24 for attitude with a range of 8-40, and 39 for performance with a range of 13-65. So scores above the mean score were considered sufficient for each KAP variable [29].

The content validity of the questionnaire was assessed by a panel of specialists, including two pharmacists, two toxicologists (with more than two years of experience in oncology), and four oncology nurses (with more than five years of experience with antineoplastic drugs). The CVI value was reported to be 0.78. The internal consistency for different instrument components was measured separately using Cronbach's alpha with a minimum internal stability requirement of 0.7 [29]. In this study, Cronbach's alpha for knowledge, attitude, and performance were determined to be 0.87, 0.57, and 0.66, respectively.

Intervention

Pre-intervention: design and development of a smartphone application

The educational application design process was carried out from March to June 2021 in two steps :1. Developing and evaluating contents, and 2. Building and evaluating the application

1. Developing and evaluating contents

One researcher (Z.H) extracted the scientific content of the software from reliable sources, including high-risk drug training protocols and standard instructions on how to work with these drugs. The scientific content was compiled based on reference books, recent articles, Occupational Safety and Health Administration (OSHA) standard guidelines, and nursing interventions of Iran's National Standard Organization. A tool was designed based on the extracted software design content, which is divided into the following sections:

a) Familiarity with high-risk drugs: types of cancer treatment, chemotherapy, ways of exposure to HDs, and complications of exposure to HDs

b) Personal protective equipment: the necessity of using PPE, gown, head covering, foot covering, gloves, mask, protective glasses, face protection

c) Drug preparation: physical conditions for drug preparation, drug preparation equipment

d) Prescribing and transferring medicine: transfer or storage of prepared drugs and half-used vials

e) Drug leakage: leakage kit, necessary measures in case of leakage into the environment, necessary measures in case of cytotoxic contamination in biological cabinet or isolator

f) Waste disposal

g) Sources

Many images and videos were used to make the educational content more exciting and compelling, adapted to the standard instructions. The content validity was confirmed by an oncologist, three nursing faculty members with theoretical and clinical training in oncology, and an educational design expert. Disagreements were discussed and exchanged until a consensus was reached. following the necessary changes in the application's content; the experts again approved the final version.

2. Building and evaluating the application

According to the educational goals and content defined previously, the research team first determined the external structure, content components' location, and application's purpose. The application's main page includes the following:

- The Lorestan University of Medical Sciences logo.
- An access menu (about us, research team members, application programming information, and communication with us).
- Six content icons.
- One resource icon.

Then a web design specialist wrote the application programming with Android language in the Android Studio environment based on Java for the Android environment and as an under-web version for the IOS environment on the iPhone phone. OncoNS was chosen for the app's name, which stands for Oncology Nursing Safety. This application was designed for installation with one click and in a short time. User-friendliness principles were considered when developing the software. This application had a very smooth and straightforward user interface. Users could quickly move between pages and click on each part of the content without needing technical information. User-friendliness principles were considered when developing the software. Camtasia Studio was used to dub the videos from English to Persian. A panel of experts designed the application's algorithm, and their opinions were discussed until a consensus was reached. Finally, the expert panel approved the final version of the application (Figure 1).

The intervention

A 20-minute face-to-face meeting was held with each participant before the intervention. At this meeting, they completed a questionnaire that assessed nurses' knowledge, attitude, and performance regarding safety standards in oncology. Next, the application was installed on the participants' mobile phones with

the help of the researcher. Explanations about the user environment of the application were presented to them. After receiving the application, participants had four weeks to read it and view its content (Figure 2). Nurses received a text message or phone call every week between 17:00 and 19:00, reminding them about the study. Immediately after and one month after the intervention, nurses were assessed for their knowledge, attitude, and performance related to oncology safety standards. The researchers were present at three-time points to complete questionnaires (before, immediately after, and one month after the intervention).

Data analysis

After collecting and entering the data in SPSS software version 26, the ratios, central tendency, and dispersion index were reported. We used the independent t-test, analysis of variance, and Mann-Whitney U to compare the mean KAP score of nurses before the intervention in terms of occupational and demographic characteristics. The repeated measures test was used to compare the mean changes in KAP scores of nurses before, immediately, and one month after the intervention. The Generalized Estimated Equations (GEE) were used to model the effect of the intervention on the KAP score by adjusting other variables. The KAP score using the Spearman correlation coefficient determined the correlation between occupational and demographic characteristics. A significance level of 5% was reported.

Results

Overall, 50 nurses from 3 university hospitals participated in this study. 92% of female participants with a mean age of 29.88 ± 6.36 years had an average hospital work experience of 5.11 ± 5.00 years. Other demographic and educational characteristics of the participants are shown in Table 1.

Table 1 Demographic and occupational characteristics of the participants

Variable		N (%)* M±SD**
Sex	Women	46 (92) *
	Men	4 (8) *
Marital status	Single	28 (56) *
	Married	22 (44) *
Employment Status	Permanent employee	17 (34) *
	Temporary employee	33 (66) *
The Oncology Association membership	Yes	7 (14) *
	No	43 (86) *
Most hours of work shifts	Morning	26 (52) *
	Evening	9 (18) *
	Morning- Evening	11 (22) *
	Morning- Night	4 (8) *
Previous training	Yes	44 (88) *
	No	6 (12) *
Age		29.88 ± 6.36**
Nursing work experience(years)		5.11 ± 5.00**
Oncology department work experience(years)		2.28 ± 1.74**
Average weekly working hours		47.08 ± 7.57**

N (%)*: Qualitative variables, M±SD**: Quantitative variables

There was a significant difference between the mean score changes in nurses' knowledge over time (P < 0.001). A significant increase was seen in the mean knowledge score during the periods before the intervention, immediately after the intervention (P < 0.001), and one month after the intervention (P = 0.001). Also, there was a significant difference between the mean score changes in nurses' attitudes over time (P < 0.001). A significant increase was seen in the mean attitude score during the periods before the intervention, immediately after the intervention (P <0.001), and one month after the intervention (P = 0.003). There was a significant difference between the mean score changes in nurses' performance over time (P < 0.001). So that a significant increase was seen in the mean performance score during the

periods before the intervention, immediately after the intervention (P < 0.001), and one month after the intervention (P = 0.001). (Table 2)

Table 2 Comparison of knowledge, attitude, and performance mean score changes of nurses at different times

P.Value	F	one month after	immediately after	Before the intervention	Variable
		M ± SD	M ± SD	M ± SD	
.001*	146.77	61.88 ± 3.45	60.08 ± 3.82	47.18 ± 8.19	Knowledge
.001*	109.78	34.98 ± 2.88	34.32 ± 3.25	30.34 ± 3.94	Attitude
.001*	132.68	52.88 ± 3.06	51.78 ± 3.15	43.60 ± 5.11	Performance

Abbreviations: M, Mean; SD, Standard deviation.

*p < .05

The Generalized Estimated Equations (GEE) model and the linear link function showed that the mean knowledge score increased to 12.90 and 14.70, and the attitude score increased to 3.98 and 4.64. The performance score increased to 8.18 and 9.28 in comparison with the score before the intervention by adjusting the effect of age, sex, marital status, previous training, work position, and work experience, increasing each period (one month) that was statistically significant (P < 0.001).

The Spearman correlation coefficient was used because the data distribution was not normal. There was a weak significant positive correlation between nurses' age with knowledge score (P = 0.006) and attitude (P = 0.049) before the intervention, but the correlation between age and performance was insignificant. Also, a weak significant positive correlation was seen between nurses' work experience with knowledge scores (P = 0.02). No statistically significant correlation was seen between attitude and performance (P > 0.05). There was a weak significant positive correlation between nurses' work experience in the oncology ward with knowledge score (P = 0.04), but no statistically significant correlation was seen between attitude score and performance (P > 0.05). Also, there was a weak significant positive correlation between nurses' work experience with antineoplastic drugs and knowledge score (P = 0.03). No significant correlation was seen between other variables with KAP scores before the intervention (P > 0.05). (Table 3)

Table 3 .Correlation of baseline scores of knowledge, attitude, and performance with demographic characteristics of the participants

*p < .05

Discussion

This study aimed to determine the effect of teaching chemotherapy safety standards on oncology nurses' KAP using a smartphone application.

Performance		attitude		Knowledge		Base score / Variable
r	P	r	P	r	P	
.07 .62		.28 .049		.38 .006*		Age (Year)
.03 .83		.26 .07		.32 .02*		Nursing work experience (Year)
.23 .108		.19 .179		.29 .04*		Oncology department work experience (Year)
.23 .106		.18 .199		.30 .03*		nurses' work experience with antineoplastic drugs (Year)
.10 .480		.19 .189		_ .11 .456		Average weekly working hours (Hour)

Knowledge

The results of the present study showed that oncology nurses' knowledge about the safe use of cytotoxic drugs was sufficient before the intervention. This result contradicted some studies. Only 4% of nurses had sufficient knowledge in a study by Bolbol et al. (2016) in Egypt [33]. However, in line with the present study, Zayed et al. (2019) showed that 67.3% of healthcare providers who administered antineoplastic drugs had adequate knowledge [13]. Due to the implementation of the intervention, an increase in nurses' awareness was observed from before the intervention till one month after. In line with this finding, a study by Crickman & Finnell (2017) in Washington showed that a 30-minute online training video for all nurses in the ward effectively increases their knowledge about improving treatment methods and reducing antineoplastic drug exposure [32]. Also, in an interventional study, Bolbol et al. (2016) found that after holding nine training sessions in the workplace, there was a significant increase in the knowledge level [33]. Also, Elsayed Mahdy et al. (2017) found in a semi-experimental study in Egypt that teaching standard instructions for working with antineoplastic drugs positively affected staff awareness about the standard principles of chemotherapy. In this study, the training was done theoretically and practically using a booklet guide and explaining its content during four face-to-face sessions [34].

Attitudes

The results of nurses' attitudes toward the safe use of antineoplastic drugs were similar to the participants' awareness. Alehashem and Baniasadi (2018) also reported the desired nurse attitude

level [29]. Khan et al. (2012) study in Pakistan reported a moderate level of nurses' attitudes toward preparing and managing chemotherapy drugs [35]. We can mention variables such as physical environment, personal characteristics, cultural environment, and attitude measurement tools as the reasons for these differences. Nurses' attitude is their reactions and behaviors towards various care issues generally influenced by various factors such as beliefs, values, customs, and culture, which indicates the type of nurses' attitudes [36]. The findings of this study showed that training through mobile applications improved nurses' attitudes toward chemotherapy safety standards before the intervention until one month after that. Along with the present study, Taghizadeh Kermani et al. (2015) in Iran showed that holding a training course in the form of 30 hours of lectures and practical training on the main concepts of nursing in oncology can improve nurses' attitudes [37]. In a study by Keat et al. (2013) in Malaysia, a significant change in nurses' attitudes toward the safe use of antineoplastic drugs was reported after a 9-month pharmacy-based intervention including a series of technical, educational, and managerial support measures consisting of administering antineoplastic drugs in a closed system, training courses, training workshops, and instruction updates that are consistent with the present study [38].

Performance

The results of the present study showed that oncology nurses' performance regarding the safe use of cytotoxic drugs was sufficient before the intervention. Consistent with this finding, in the study of Alehashem and Baniasadi (2018), the nurse's performance score was reported to be satisfactory [29]. However, according to the results obtained in the study of Zayed et al. (2019) and the study of Keat et al. (2013), nurses had poor performance in this field and did not correctly follow international standards [13, 38]. Possible reasons for this difference could be the different places of study, the presence or absence of necessary equipment in the workplace, different tools used to measure staff performance, and previous training of the samples. An improvement in the performance level of nurses was observed before the intervention until one month after. Bolbol et al. (2016) also stated that participating in the training sessions can improve nurses' performance in working with antineoplastic drugs [33]. Also, Al-Attar and Al-Gannem (2015) stated that training positively affects nurses' performance [16]. The interventional study of Mishra et al. (2021) also showed that the use of PowerPoint and discussion methods had improved the nurse's performance regarding the safe use of antineoplastic drugs [31].

The nurses' training has been done traditionally in most studies in this field. Continuing Medical Education (CME) is an essential principle in nursing professionalization, which can effectively improve nurses' performance; E-learning can play an essential role in continuing medical education programs [39]. Due to the benefits of modern education, such as reduced training costs, accessibility in any time and place, reduced communication costs, and so on[24, 25], the use of E-learning, especially mobile applications for nurses who are busy with work, is more convenient and accessible. In confirmation of the contents mentioned in the study of Khoshnoodifar et al. (2009), it was found that the E-learning method can increase nurses' knowledge scores more than traditional education [24]. Also, many studies have

shown high satisfaction among people and positive education results in using E-learning alone or with traditional education in medical sciences [23, 39].

STUDY LIMITATIONS

We faced a restricted sample size due to the limited number of nurses in the chemotherapy wards of the hospital affiliated to Lorestan University of Medical Sciences where was the research environment.

Conclusion

According to the results of the present study, the training of chemotherapy safety standards using the OncoNS smartphone application had a desirable effect on the KAP of oncology nurses. Pay attention to nurses' safety and promotion methods to prevent these drugs' side effects. Therefore, implementing such programs requires training in safety standards before starting work in the oncology departments and continuing this training during service. Due to the effectiveness of the application and, on the other hand, the problems of nurses such as high workload, interference of face-to-face retraining with their working hours, leisure, and family issues, the use of the E-learning method is recommended for training nurses and other health care providers. We hope that nursing managers help nurses improve their knowledge, attitude, and performance in occupational safety by using proper educational planning, especially new educational methods such as E-learning in the form of a smartphone application.

Abbreviations

KAP: Knowledge, Attitude, and Performance

HDs: Hazardous drugs

NIOSH: National Institute for Occupational Safety and Health

ASHP: American Society of Hospital Pharmacists

ONS: Oncology Nursing Society

OSHA: Occupational Safety and Health Administration

PPE: Personal Protective Equipment

Declarations

Ethics approval and consent to participate

This study was conducted observing ethical considerations in line with the Helsinki Declaration. The study protocol was approved by the ethics committee of the Deputy of Research and Technology at Lorestan University of Medical Sciences (IR.LUMS.REC.1399.042). The aim and method of the study were

explained to the nurses, and the first author answered their questions. They could withdraw from the study without affecting their caring process. The written informed consent form was signed by those nurses who willingly agreed to participate in this study. Confidentiality and anonymity were ensured throughout the study process.

Consent for publication

Not applicable.

Availability of data and materials
Data is available upon reasonable request from the corresponding author

Competing interests

The authors have no conflicts to declare

Authors' contributions
Study concept and design: H.Z., G.F., H.Sh., G.N., and B.M; analysis and interpretation of data: B.M., H.Z., and G.F.; drafting of the manuscript: H.Z., G.F., H.Sh., and B.M;
Critical manuscript revision for important intellectual content: H.Z., G.F., H.Sh., G.N., and B.M. All authors have read and approved the manuscript.

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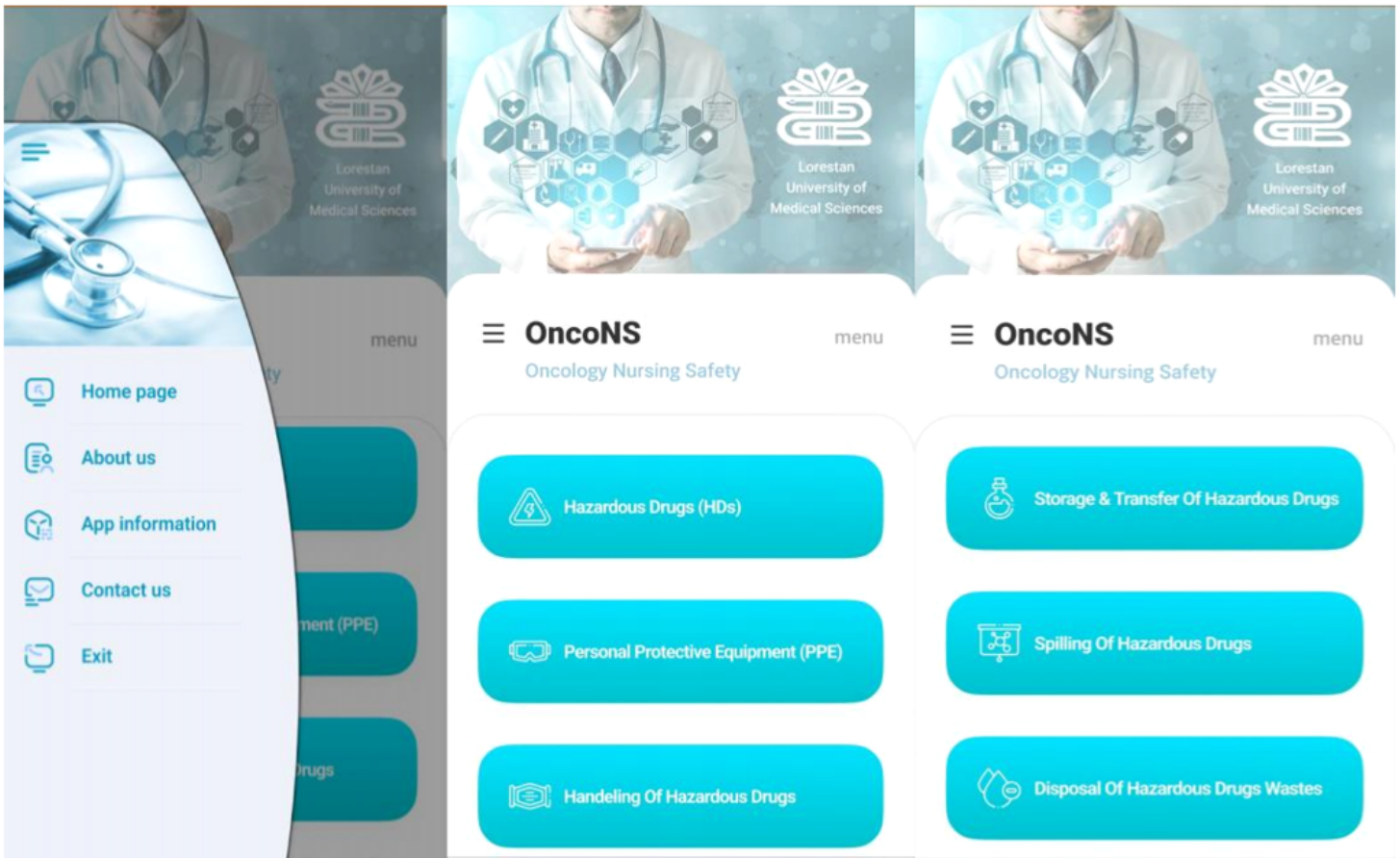
Figures

Figure 1

Photos of the OncoNS application

The first week:
  Familiarity with anti-neoplastic drugs - personal protective equipment

Second week:
  Preparation of drugs - Prescription and transfer of drugs

Third week:
  Leakage of drugs

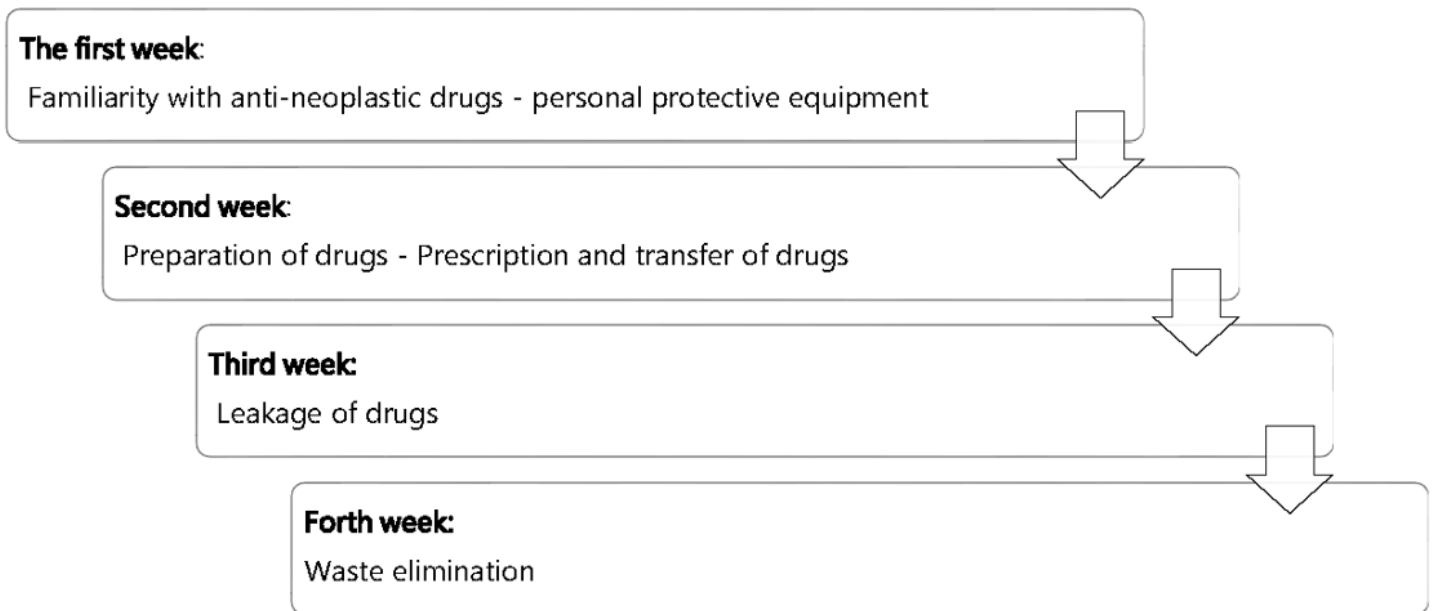**Forth week:**
  Waste elimination

Figure 2

The schedule flowchart for studying and observing the application