Original Article

The Effect of Smartphone Ventilator Training Application on the Knowledge and Skills of Intensive Care Unit Nurses

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Abstract

Aim: Mechanical ventilation is widely used in the intensive care units (ICUs). Nurses need to learn how to use this device. This study aimed to develop a ventilator training application software (VTApp) on the smartphones and to study its effect on the knowledge and skills of nurses working in the ICUs. **Materials and Methods:** This quasi-experimental study was carried out on fifty nurses working in ICUs of Shahid Beheshti Hospital in Kashan, Iran. First, the VTApp was designed and developed based on the results of the needs assessment on the Android platform. Participants were asked to install the VTApp on their smartphones and use it regularly. The scores of ICU nurses' knowledge and skills, before and after the intervention, were compared using the Wilcoxon test at a significant level of $P < 0.05$. **Results:** The usability assessment of the VTApp showed that it was at a desirable level according to the IT experts' opinions (mean score was 75.3 out of 100). Based on the results of the study, the mean scores of nurses' knowledge and skills in the preintervention stage were 12.22 ± 3.34 and 21.36 ± 6.31, respectively. These mean scores increased to 16.5 ± 2.8 and 28.38 ± 6.21 after intervention, which was significant for both variables ($P < 0.0001$). **Conclusions:** The use of the smartphone's VTApp increased the knowledge and skills of nurses in ICUs. Further studies are recommended.

Keywords: Education, knowledge, nursing, software, ventilator

Introduction

Mechanical ventilation is widely used regularly in the intensive care units (ICUs). This device is used aiming to normalize arterial blood gases, maintain acid and base balance, ventilate, oxygenate, and decrease the work of breathing.[1] Nurses play the most significant role in checking, maintaining, and supervising the work of ventilator.[2] The ICU nurses, as the first-line caregivers, must seriously consider many issues related to working with ventilators, including the ventilator performance, the adequacy of the mode, and preventing complications. Therefore, these nurses need adequate training about ventilators (i.e., adjusting the ventilator, types of modes, and ventilator alarms).[1,3] Bachelor of Science (BSc) nursing students are narrowly taught about mechanical ventilation due to the short time and the broad curriculum content in ICUs; therefore, these students obtain limited information about how to work with a ventilator.[4] A study conducted in 2018 reported senior nursing students' poor skills in working with ventilators.[5] The ICU nurses usually ask others to interpret the ventilator information. This can be life threatening for patients because they may be exposed to inadequate or inappropriate ventilation for a long time.[6]

Currently, ventilator training references are available in the form of books and pamphlets. In addition, relevant short-term retraining programs are being implemented in

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hospitals due to the importance of the issue.[7,8] However, in face-to-face training (synchronous method), the problem of the nurses' inability to attend such classes was observed due to workloads, rotating shifts, and the costs of participating. Moreover, the training materials are limited to the class time and are not always available to the nurses and will be forgotten after a while.[9] Methods of instruction continually develop to meet the ever-changing needs of instructors and learners.[10] Asynchronous instruction has become more common in recent years. Asynchronous education is a learner-centered instructional method where interactions between trainers and learners are independent of place and time. Results of studies indicated that nurses need to integrate various education procedures including asynchronous activities.[11] However, the use of technology can be a solution to provide adequate training to nurses.[12,13]

Nowadays, smartphones enjoy the new technologies and extensive capabilities, which can be used in nursing courses. It provides students with quick access to training materials and instructions, anytime anywhere, during clinical conferences, classes, or in the patients' rooms. Smartphone applications can be tools for nursing education and training.[14,15] These applications have a wide range of different uses, which empower patients and health-care providers. It helps them to deal with diseases through timely monitoring and treatment, regardless of the locations where the patient or the health-care provider attends.[16-18] A study was performed to examine the application of mobile learning (M-learning)-based platforms as a kind of content delivery among critical care nurses versus regular classrooms. A posttraining questionnaire was circulated to understand their experience and perception. Results demonstrated that the nurses showed positive behavior intention to using procedures for learning.[19] Furthermore, a researcher (2017) evaluated the efficacy of mobile application on scores of the knowledge and skills of nursing students in simulated performance when providing care. Results showed that smartphone-based education group showed higher scores on skills compared to lecture based education group. The scores of satisfaction and knowledge were also higher in smarthphone group although the difference was not significant. The participants had positive view toward the use of technology,[20] another study also found that medical students had satisfaction in using mobile application for education.[21] In Australia, a study was performed to examine the effect of the academic component, mammography online (MO), for the pre- and postprogram evaluations. Results of qualitative content analysis showed that MO fulfilled the necessities of the academic component of the certificate of clinical proficiency in mammography but did not supersede the need for the clinical components.[22]

So far, several studies have revealed the positive effects of smartphone-based technologies on nursing training.[14,23,24] There are few ventilator training applications available, which can be installed on the smartphones. Furthermore, these existing training programs contain old and superficial materials which cannot meet the training needs of nurses. Furthermore, few researches have been conducted on training nurses for ventilator and mechanical ventilation using smartphone applications. Therefore, this study was performed aiming to determine the effect of smartphone ventilator training application on the knowledge and skills of ICU nurses.

Materials and Methods

This quasi-experimental study was conducted on ICU nurses working in Shahid Beheshti Hospital in Kashan, Iran, 2019.

In order to perform the study, at the first a ventilator training application software (VTApp) was developed and its usability was evaluated. In so doing, three ICU head nurses as well as five faculty members were consulted and asked for their expert opinions. After approving the VTApp main categories, the researchers provided scientific content and asked the eight abovementioned authorities to approve them. The content and functional requirements of VTApp included mechanical ventilation guidelines, ventilator parameters and settings, ventilator modes, ventilator alarms, ventilator graphs, detecting patient–ventilator asynchrony, reading the respiratory graphs, ventilator settings in patients with different diseases, adverse effects of ventilator on body systems, and ventilator weaning. More results are presented in Table 1.

The collected data and ways to arrange the content were presented to Hamrahe Fadak Company, which is a well-known and active company in computer science and application design. This way, the VTApp was designed on the Android platform using the Java programming language and the SQLite database. The usability of the VTApp was evaluated by using the System Usability Scale (SUS), which consists of ten items based on a five-point Likert scale from 1 to 5 (strongly agree to strongly disagree). This scale has already been translated into Persian and its reliability was calculated to be 0.77.[25,26] The total score of SUS is between 0 and 100. In interpretation of usability scores, score <50 is considered unacceptable, 50–70 is considered borderline acceptable, and score above 70 is considered acceptable.[27] To determine the usability, this scale was distributed among five information technology engineer experts who had at least a BSc degree and at least 2 years of work experience. The results of the SUS showed a mean score of 75.3 ± 5.25, which represented an acceptable range.

The population of this study were the ICU nurses who are working in Shahid Beheshti Hospital and met the inclusion criteria (having at least 6 months of ICU work experience, having at least a BSc in nursing, and having a smartphone with Android operating system). They were asked to sign a written consent form for their agreement to obtain information through VTApp to work with the ventilator. The population included 80 ICU nurses that 8 of them refused to participate in the study, and therefore, the study was performed on 72 ICU nurses. In a face-to-face training session, the ICU nurses were taught how to properly use the VTApp and they were then asked to install this application on their smartphones. They

Table 1: The ventilator training application software data content and functional requirements

Mechanical ventilation guidelines (definition and purposes of ventilation, reasons for applying ventilation, basics of the ventilator, and definitions of support ventilation)
Ventilator parameters and settings (RR, inspiratory airflow (V'), VT, I:E ratio, FIO_2, ventilator sensitivity, respiratory waveforms, PEEP, etc.)
Ventilator modes (mandatory/control ventilation, assist ventilation, CMV, SIMV, PSV, APRV, and PCIRV)
Ventilator alarms (such as exhaled tidal volume, pressure, FIO_2, and apnea)
Ventilator graphs
Detecting patient-ventilator asynchrony reading the respiratory graphs
Ventilator settings in patients with rare diseases (myocardial ischemia, hypovolemic shock, neurological patients, ARDS patients, etc.)
Awareness of the adverse effects of using a ventilator on body systems such as the cardiovascular, kidney, respiratory, digestive systems, and the psychological problems
Ventilator removal (criteria and steps)
Basic settings (the nurse asks basic information from the patient, including height, weight, gender, and initial diagnosis of the disease, and enters the data into the VTApp. The application then provides the nurse with the default settings to be adjusted on the ventilator)
The VTApp enjoys these features: search, bookmark, note-taking for each content, and displaying text-related images
"Time count" (as a feature of calculating the number of hours a nurse uses the application. Upon nurses' consent and confirmation, results of the "Time count" will be sent to the researchers via SMS)

RR: Respiratory rate, PEEP: Positive end-expiratory pressure, VT: Tidal volume, FIO_2: Oxygen concentration, CMV: Continuous mandatory ventilation, SIMV: Synchronized intermittent mandatory ventilation, PSV: Pressure support ventilation, APRV: Airway pressure release ventilation, PCIRV: Pressure-controlled inverse-ratio ventilation, ARDS: Acute respiratory distress syndrome, SMS: Short message service

were also asked to use the VTApp during their work hours and review its contents. It should be noted that the duration of using the mobile application was recorded in program, and nurses who did not use the mobile application were excluded from the study.

In order to evaluate nurses' knowledge and skills, participants completed the abovementioned test before installing the VTApp and 2 weeks after it (pretest and posttest).

However, the knowledge and skills of participants about mechanical ventilation were measured using a researcher-made test which included two parts, namely a ventilator knowledge test (VKT) and a ventilator skills test (VST). Ventilator knowledge consisted of twenty short-answer and multiple-choice questions about ventilator. This test had been developed and approved by the faculty members of the Nursing Department at Kashan University of Medical Sciences. The VKT had a scoring range from 0 to 20 (each correct answer scored one point and there was a score of 0 for incorrect answers). The VST, Five clinical scenarios and three graphs about ventilators were used for ventilator skill test. For assessing nurses' skills in clinical scenarios, by introducing a number of patients' clinical features, nurses were asked to determine six parameters related to ventilator settings. Parameters included peak inspiratory pressure, positive end-expiratory pressure ventilation, inspiratory–expiratory ratio, fractional inspired oxygen, tidal volume, and respiratory rate. Each correct answer scored one point and there was a score of 0 for incorrect answers (the total score for each scenario was between 0 and 6 and for all five scenarios was between 0 and 30). For assessing nurses' skills in interpretation on the interpretation of ventilator graphics, three graphs related to patients' condition presented for nurses. Participants received two points for each correct reading/interpretation graph (total score for three graphs was between 0 and 6), hence an ultimate VST score ranging from 0 to 36. This test was approved by five experts who specialized in working with ventilators.

Descriptive statistical analyses (frequency and mean) were used to describe the findings of demographic data. The Kolmogorov–Smirnov test was used to check the normal distribution of the data. The nurses' knowledge and skills scores based on their qualitative characteristics were examined using independent *t*-test and Mann–Whitney U-test. The correlation between quantitative characteristics of nurses with their ventilator knowledge and skills was calculated using Spearman's correlation coefficient. The scores of ICU nurses' knowledge and skills, before and after the intervention, were compared using the Wilcoxon test. The level of significance was set at $P < 0.05$.

This research has been approved by the Ethics Committee of Kashan University of Medical Sciences (IR-KAUMS.NUHEPM.REC.1398.034). The research objectives were explained to the participants, and written informed consent forms were obtained from each of them. Participants were assured of their right that they were free to participate in the study or to leave it anytime. The confidentiality of the data was retained by the researchers.

Results

In this quasi-experimental study, only 50 nurses (69.4%) used the VTApp during the study and 22 nurses (30.6%) did not use it. The participants also stated that the most important obstacles in using the VTApp were workload and limited time (36.7%). However, data analysis was performed on fifty nurses who completed the study. Tables 2 and 3 show the findings about participants' demographic information and its relationship with scores of their knowledge and skills. Results showed that participants included both women ($n = 43$) and men ($n = 7$) and the mean age was 33.56 ± 5.19 years. The mean score

Table 2: Participants' knowledge and skills at different measurement time points based on their qualitative characteristics

Demographic variables	*n* (%)	Before intervention				After intervention			
		Knowledge		Skills		Knowledge		Skills	
		Mean±SD	*P*[a]	Mean	*P*[b]	Mean	*P*[b]	Mean	*P*[b]
Sex									
Male	7 (14)	13.28±3.86	0.21	24.28±3.49	0.18	16.00±2.32	0.62	27.85±12.38	0.81
Female	43 (86)	12.04±3.27		20.88±6.54		16.58±2.96		28.46±4.79	
Educational level									
BSc	45 (90)	12.02±3.40	0.39	21.24±6.51	0.7	16.46±2.65	0.8	28.28±6.50	0.75
MSc	5 (10)	14.00±2.23		22.40±4.56		16.80±4.91		29.20±2.58	
Ventilator training course experience									
Yes	29 (58)	11.75±3.46	0.36	20.48±6.34	0.34	16.42±2.64	0.95	27.89±6.73	0.56
No	21 (42)	12.61±3.1		22.14±6.07		16.47±3.24		28.85±5.65	
Overtime work (h)									
<50	26 (52)	12.38±2.85	0.72	22.30±5.09	0.27	17.07±2.75	0.14	29.57±4.09	0.15
≥50	24 (48)	12.04±3.86		20.33±7.39		15.87±2.93		27.08±7.78	

[a]The results of the independent-sample *t*-test, [b]The results of the Mann-Whitney U-test. SD: Standard deviation

Table 3: Participants' knowledge and skills at different measurement time points based on their quantitative characteristics

Variables	Mean±SD	Before intervention		After intervention	
		Knowledge scores *R*[a] (*P*)	Skills scores *R*[a] (*P*)	Knowledge score *R*[a] (*P*)	Skills score *R*[a] (*P*)
Age	33.56±5.19	1.154 (0.286)	0.134 (0.352)	-0.161 (0.264)	0.247 (0.084)
Work experience (years)	9.89±4.79	0.135 (0.351)	0.125 (0.388)	-0.097 (0.505)	0.223 (0.119)
Daily use of smartphone (min)	147.85±119.79	0.105 (0.55)	0.201 (0.247)	0.128() 0.463	0.087 (0.620)

[a]The results of Spearman's correlation test. SD: Standard deviation

Table 4: Pre- and posttest results of participants' knowledge and skills

Variable	Type	Pretest	Posttest	*Z*	*P*[a]
Knowledge		12.22±3.34	16.5±2.88	5.628	0.0001
Skill	Scenario score	19.28±5.88	24.7±5.05	5.334	0.0001
	Graph Reading (interpreting)	2.08±1.8	3.68±1.91	3.925	0.0001
	Total	21.36±6.31	28.38±6.21	5.292	0.0001

[a]The results of Wilcoxon's test

of the work experience was 9.89 ± 4.79 years. Most of the participants ($n = 45$) had a BSc degree. In addition, 29 nurses had attended ventilator training courses before the beginning of the study and participating nurses used their smartphones for an average of 147.85 ± 119.79 min per day.

Results showed none of the demographic characteristics related to nurses' knowledge and skills at two time measurements (before and after the intervention). Based on the results of this study, the means of nurses' knowledge and skills scores before the intervention were 12.22 ± 3.34 (out of 20) and 21.36 ± 6.31 (out of 36), respectively, which increased to 16.5 ± 2.88 and 28.38 ± 6.21 after the intervention. Wilcoxon test showed that this increase for both knowledge and skills variables was statistically significant ($P < 0.001$). Nurses' skills score was a combination of two scores, i.e., the nurse's ability in adjusting the VTApp default settings (scenarios) and graphs' reading/interpreting [Table 4]. Both of which increased significantly after the intervention.

Discussion

The usability assessment of this application showed that it had a desirable level of usability. Furthermore, smartphone VTApp had a statistically significant positive effect on ICU nurses' knowledge and skills. A study in Iran demonstrated that 35.6% of the participating nurses had not attended any retraining programs, the most important reasons for which were insufficient time and their low quality.[28]

Currently, there are many health-care applications in the world,[29,30] while specialized nursing applications have not received due attention in Iran, particularly those designed in Iran in Persian language.[31] Perhaps, most of the existing applications are related to drug selection and calculations.[14] However, in

other areas, especially working with ventilators, there are few applications. A study in Iran showed that senior nursing students were least skilled at working with ventilators among other clinical skills. These nursing students stated that their ability to work with a ventilator had been at an unacceptable level.[5] This lack of information about working with ventilators can also be seen among the ICU nurses in other countries too. In a study in Australia, 63% of the ICU nurses had not received any training on how to work with a ventilator before commencing their work in these units. They had also suffered from a lack of knowledge about invasive ventilation.[4,32] The overall mean of the SUS scores was 75.3, which was within an acceptable range. A study showed that nursing students would easily use smartphones for training purposes in clinical settings. Furthermore, according to this study, most nurses expressed their satisfaction in using the VTApp and they confirmed that nurses must benefit from such applications as a training method.[5] These data indicate that this training application has enjoyed a good level of quality. In a study on nursing education and students' satisfaction using an emerging mobile learning tool, 32.4% of the students said that educational content was very useful for them, 14.7% expressed partial satisfaction, and 52.9% stated that they were not able to use it.[33] This study revealed that the quality of the educational content and the curriculum should be improved and its usability must be enhanced.

Based on the results of the current study, the overall mean score of nurses' knowledge and skills increased significantly after the intervention. In a study conducted by Mireles-Cabodevila *et al*. in 2017, nurses watched an educational video on ventilator graphs which increased their skills in reading graphs.[15] This indicates the advantages of using multimedia training methods. Another study demonstrated the effectiveness of educational programs on ICU nurses' knowledge and skills in adhering to guidelines to prevent ventilator-associated pneumonia.[10] In addition, a study investigated the effect of traditional versus application-based teaching on operating room students' learning and practical skills. Results showed that students who were trained with applications scored higher in terms of knowledge and skills.[28] In a study, 82.6% of the students perceived M-learning as a flexible method of learning as it can be done anytime, anywhere. However, 75% of the students are willing in future to use it in their learning.[34] An integrated approach to e-learning amplitude-integrated electroencephalography (aEEG) in neonatal intensive care units (NICUs) was performed among a total of 37 NICU staff. Results indicated a statistically significant improvement in the subjective knowledge score of the participants. Among the participants who completed the study, 96.0% mentioned that the teaching was well structured and 70.4% could interpret normal aEEG with confidence.[35] Contrary to the above findings, a study was conducted by PYo *et al*. to examine the effect of an advanced cardiac life support (ACLS) application through smartphone on nurses' knowledge and learning satisfaction. The samples were selected from nurses in medical-surgical ICUs and emergency room. The interventional and control groups included 50 nurses who were self-learned with ACLS simulation application through smartphone and 71 nurses who used traditional learning resources, respectively. Nurses' knowledge and learning satisfaction were assessed before and after the intervention. Results showed that the scores of ACLS knowledge were lower in the intervention group compared to the control group, and also in the control group, the contents of education were reliable than the interventional group. However, learning satisfaction showed no statistical difference between the two groups, but the interventional group showed higher interest than the control to the method of education. This study showed that training with the new methods significantly increased nurses' interest in ACLS education. Therefore, more applications with high quality for smartphones should be developed to provide self-learning for nurses and improve care quality.[36]

In our study, a ventilator-specialized training application successfully was designed and developed and there were no restrictions on the number of uses of the application. According to the study, most nurses used Android smartphone and increased the knowledge and skills of them. Lack of continued cooperation from all nurses due to workload was another limitation of the study. However, if there is financial support, it is possible to design such an application for the smartphones which use the operating system too. Nevertheless, the fact that the VTApp can only be installed on the smartphones with Android operating system is one of the limitations of this research.

Conclusions

Considering the advantages of the smartphone's VTApp such as increased the knowledge and skills of nurses in ICUs, it can be provided for ICU nurses. Furthermore, given that few studies have been conducted on the impact of educational ventilator-specialized training application on learning the clinical skills of ICU nurses, it is recommended that more studies be conducted to compare this method with other self-taught methods with a larger sample size.

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Conflicts of interest

There are no conflicts of interest.

References

1. Grossbach I, Chlan L, Tracy MF. Overview of mechanical ventilatory support and management of patient- and ventilator-related responses. Crit Care Nurse 2011;31:30-44.

2. Enrico B, Cristian F, Stefano B, Luigi P. Patient-ventilator asynchronies: Types, outcomes and nursing detection skills. Acta Biomed 2018;89 Suppl 7:6.
3. Al-Sayaghi KM. Prevention of ventilator-associated pneumonia. Saudi Med J 2014;35:269-76.
4. Guilhermino MC, Inder KJ, Sundin D, Kuzmiuk L. Education of ICU nurses regarding invasive mechanical ventilation: Findings from a cross-sectional survey. Aust Crit Care 2014;27:126-32.
5. Forouzi MA, Alimirzaei R, Dehghan M, Heidarzadeh A. Evaluation of nursing students' clinical skills in intensive care units. J Nurs Educ 2018;6:57-63.
6. Shahidi Far S, Emami Zeydi A, Taghipour B, Sharif Nia H, Soleimani MA, Hassan Zadeh Kiabi F, *et al.* Evaluation of critical care nurses' knowledge of evidence-based guidelines for prevention of ventilator-associated pneumonia. Milit Caring Sci 2015;2:14-23.
7. Chlan L, Tracy MF, Grossbach I. Achieving quality patient-ventilator management: Advancing evidence-based nursing care. Crit Care Nurse 2011;31:46-50.
8. Jam Gatell MR, Santé Roig M, Hernández Vian Ó, Carrillo Santín E, Turégano Duaso C, Fernández Moreno I, *et al.* Assessment of a training programme for the prevention of ventilator-associated pneumonia. Nurs Crit Care 2012;17:285-92.
9. Hampton D, Pearce PF, Moser DK. Preferred methods of learning for nursing students in an on-line degree program. J Prof Nurs 2017;33:27-37.
10. Jansson M. The Effectiveness of Education on Critical Care Nurses Knowledge and Skills in Adhering to Guidelines to Prevent Ventilator-Associated Pneumonia. Oulu University publication; 2014.
11. Fox OH. Using voice thread to promote collaborative learning in on-line clinical nurse leader courses. J Prof Nurs 2017;33:20-6.
12. Maag M, editor. iPod, uPod? An emerging mobile learning tool in nursing education and students' satisfaction. In: Proceedings of the 23rd Annual Ascilite Conference: Who's learning? Whose Technology? The University of Sydney: ASCILITE; 2006.
13. Bishop R, Joy B, Moore-Clingenpeel M, Maa T. Automated audiovisual feedback in cardiopulmonary resuscitation training: Improving skills in pediatric intensive care nurses. Crit Care Nurse 2018;38:59-66.
14. Phillippi JC, Wyatt TH. Smartphones in nursing education. Comput Inform Nurs 2011;29:449-54.
15. Mireles-Cabodevila E, Dugar S. On the need for standard definitions and education to optimize patient-ventilator interactions. Respir Care 2017;62:248-9.
16. Mistry V. Critical care training: Using Twitter as a teaching tool. Br J Nurs 2011;20:1292-6.
17. West DM. Improving health care through mobile medical devices and sensors. Brookings Inst Policy Rep 2013;10:1-13.
18. Kvedar J, Coye MJ, Everett W. Connected health: A review of technologies and strategies to improve patient care with telemedicine and telehealth. Health Aff (Millwood) 2014;33:194-9.
19. Kumar PN, D'Silva HE, Swapna B. Mobile technology platform providing continuous education. Int J Civil Eng Technol 2019;10:1233-40.
20. Kim SJ, Shin H, Lee J, Kang S, Bartlett R. A smartphone application to educate undergraduate nursing students about providing care for infant airway obstruction. Nurse Educ Today 2017;48:145-52.
21. Briz-Ponce L, Pereira A, Carvalho L, Juanes-Méndez JA, García-Peñalvo FJ. Learning with mobile technologies – Students' behavior. Comput Hum Behav 2017;72:612-20.
22. Kiegaldie D, Shaw L. Mammography online: An evaluation of an online mammography education program for radiographers. J Med Imaging Radiat Sci 2020;51:579-89.
23. Raman J. Mobile technology in nursing education: Where do we go from here? A review of the literature. Nurse Educ Today 2015;35:663-72.
24. Wyatt TH, Krauskopf PB, Gaylord NM, Ward A, Huffstutler-Hawkins S, Goodwin L. Cooperative m-learning with nurse practitioner students. Nurs Educ Perspect 2010;31:109-13.
25. Brooke J. SUS-A quick and dirty usability scale. Usability Eval Ind 1996;189:4-7.
26. Bangor A, Kortum PT, Miller JT. An empirical evaluation of the system usability scale. Int J Hum Comput Interact 2008;24:574-94.
27. Bangor A, Kortum P, Miller J. Determining what individual SUS scores mean: Adding an adjective rating scale. J Usability Stud 2009;4:114-23.
28. Khazaei Jalil S, Shahbazian B, Montazeri AS, Abbasi A. The impact of educational software designed on operating room students' learning of practical skills. Res Med Educ 2016;7:13-9.
29. Mosa AS, Yoo I, Sheets L. Healthcare applications for smartphones. In: Encyclopedia of Mobile Phone Behavior. Hershey, PA: IGI Global; 2015. p. 792-806.
30. Chen T. Assessing factors critical to smart technology applications to mobile health care − The fgm-fahp approach. Health Policy Technol 2020;9:194-203.
31. Bonabi M, Mohebbi S, Martinez-Mier E, Thyvalikakath T, Khami M. Effectiveness of smart phone application use as continuing medical education method in pediatric oral health care: A randomized trial. BMC Med Educ 2019;19:1-7.
32. Guilhermino MC, Inder KJ, Sundin D. Education on invasive mechanical ventilation involving intensive care nurses: A systematic review. Nurs Crit Care 2018;23:245-55.
33. Maag M. iPod, uPod? An emerging mobile learning tool in nursing education and students' satisfaction. In: Who's Learning? Whose Technology?. Proceedings of the 23rd annual ascilite conference, University of Sydney; 2006. p. 483-92.
34. Salameh B, Ewais A, Salameh O. Integrating M-Learning in Teaching ECG Reading and Arrhythmia Management for Undergraduate Nursing Students. 2020.
35. Poon WB, Tagamolila V, Toh YP, Cheng ZR. Integrated approach to e-learning enhanced both subjective and objective knowledge of aEEG in a neonatal intensive care unit. Singapore Med J 2015;56:150.
36. Pyo MY, Kim JY, Sohn JO, Lee ES, Kim HS, Kim KO, *et al*. The effects of an advanced cardiac life support training via smartphone's simulation application on nurses' knowledge and learning satisfaction. J Korean Clin Nurs Res 2012;18:228-38.