Citation

Huang XL , Tsao Y, Chung C-H, & Creedy DK. (2020) Effects of a mobile phone application for graduate nurses to improve central venous catheter care: A randomized controlled trial. Journal of Advanced Nursing. doi:10.1111/jan.14735

Abstract

Aim: To develop and test a mobile phone application (app) for graduate nurses on the use and care of Central Venous Catheters.

Design: A randomized controlled trial was conducted at a teaching hospital in the central east coast of Taiwan.

Methods: Recruitment occurred from 1 August 2019 – 31 October 2019. All graduates (N = 90) attending a 2-week induction program attended a lecture and completed a 10-item questionnaire on Central Venous Catheter assessment and care at the end of week 1 (Time 1). Volunteers were then randomly allocated to receive a link to the learning app on their mobile phone (N = 39 Group A) or control condition (N = 40 Group B). One week later, all graduates completed the knowledge assessment (Time 2) and a simulated clinical assessment with a mannequin. Skills were assessed using an 11-item, direct observation of procedural skills form. Only data from consenting participants were analyzed.

Results: Compared with controls, nurses receiving the intervention reported significantly better knowledge (t = -7.98, $p < 0.001$, CI = 20.9 ~ 34.8) and skills scores ($t = 2.83$, $p = .006$, CI= 1.14 ~ 6.61). More frequent use of the mobile phone app was associated with higher knowledge ($r = .39$, $p = .02$, CI= .11 ~ .99) and skills ($r = .42$, $p = .008$, CI = .17 ~ 1.03).

Conclusion: Mobile app instruction for graduate nurses on Central Venous Catheter care increased specific knowledge and skills compared with conventional methods of instruction.

Impact statement: Implementation of mobile-phone application technology can be considered a feasible means to proactively provide training and education. Mobile phone apps could be developed for a range of clinical procedures and various settings. Future studies with a larger sample and a longitudinal follow-up are warranted to confirm results.

Key words: Central venous catheters, knowledge, mobile phone application, graduate nurses, clinical skills, nursing

Introduction

There is growing evidence that many graduate nurses experience stress during the transition to practice due in part to a perceived lack of professional nursing competence, fear of making mistakes and being in unfamiliar situations (Labrague, & McEnroe-Petitte, 2017; Willman, Bjuresäter, & Nilsson, 2020). Most graduate nurses report deficiencies in some aspects of their nursing knowledge and clinical skills and/or inability to apply what they have learned to actual clinical practice (Hezaveh, Rafii, & Seyedfatemi, 2014). A lack of professional nursing competence is strongly associated with an increased risk of patient harm and a significant predictor of poor patient outcomes (Aiken, et al., 2014). Hospital based graduate transition or induction programs usually aim to educate and support new nurses towards work-readiness but often rely on traditional learning and teaching approaches.

Background

Central venous catheterization (CVC) is one of the most common procedures undertaken in the acute hospitals, especially in intensive care units (ICU). In the United States, over 15 million catheter-days/year are recorded in the ICU alone (Young, 2020). Application of CV catheters is accompanied with risks of complications, such as hemorrhage, thrombosis and bloodstream infections (Kornbau, Lee, Hughes, & Firstenberg, 2015). These complications are associated with significant healthcare burden in regard to cost, increased hospital days and decreased patient quality of life (Cai, Zhu, Sun, Cao, & Wu, 2018; Chung, Wang, Wu, & Hsieh, 2019). Graduate nurses therefore need knowledge and skills to assess a patient's eligibility for CVC insertion and effectively prevent adverse outcomes by applying various clinical procedures (such as aseptic protocols, hand hygiene and standard precautions).

Mobile technology has spread rapidly across the world. It is estimated that more than 5 billion people have mobile devices and over half of these connections are smartphones (Taylor & Silver, 2019). The use of mobile devices for academic learning, information sharing, and entertainment has become a striking global phenomenon and an integral part of the life of young professionals. Online collaborative learning can be either synchronous or asynchronous, with the latter enabling individuals to engage in learning at a location and time convenient for them (Basak, Wotto & Bélanger, 2018). When aided by mobile devices, learners can access relevant learning materials anywhere, any time (Liu & Hwang 2010).

According to a recent review of seven randomized controlled trials and seven quasi-experimental studies with undergraduate nursing students, smartphone-based applications (known as apps) were found to promote students' learning motivation and satisfaction but not clinical knowledge and skills (Lee, Min, Oh, & Shim, 2018). Common types of mobile phone applications used by students included medication calculations and administration, medical laboratory references and medical dictionaries (Rouleau, et al., 2019). There is relatively little research on the use of technology to teach management of CVC. Two studies examined the effects of integrated mobile devices (Galvão, & Püschel, 2012) or simulation equipment (Soffler, Hayes, & Smith, 2018) on CVC care among undergraduate medical students and found the interventions produced superior results compared with traditional didactic lecture or printed resources.

Although previous studies reported a positive influence of mobile technologies on students' educational engagement, few have been conducted with clinicians (Guo, Watts & Wharrad, 2015). Implementation and evaluation of mobile technology in undergraduate nursing education is in its infancy (Lee et al. 2018) and the same could be argued about the efficacy of mobile technology in continuing professional education.

There continues to be a lack of evidence on the impact of mobile phone-based educational applications on clinical knowledge and skills (Lee et al., 2018).

Aim

The aims of the study were to develop and test a mobile phone application (app) for graduate nurses on the use and care of Central Venous Catheters.

Study design and setting

A randomized controlled trial was conducted at a teaching hospital located in the central east coast of Taiwan. At the participating site, around 5% of inpatients (nearly 350 cases per year) had a CVC inserted (Wang, Chung, Wu, & Hsieh, 2019). Figure 1 shows a schematic overview of the study design and participant flow.

Sample size

The minimum sample size for analyzing differences between two groups with a two-tailed test was calculated using G* Power (version 3.1.9.2). With a statistical significance level of 0.05, power of 0.8, effect size of 0.5 and an allocation ratio of $n_2/n_1 = 1$, the sample size was calculated to be 128. A priori power analysis for a matched pairs design conducted by Lee et al. (2016) yielded a minimum sample size of 68. Considering the limited number of employed graduate nurses (about 100-120 annually, with around two-thirds joining the nursing workforce in August) and potential dropout from the study, we assumed a sample size of 80 participants was appropriate for the study. This estimation of 40 in each group was confirmed in a post hoc power analysis with our paired, within-subject data ($1-\beta = 87\%$).

Eligibility criteria

Inclusion criteria required participants to be 18 years of age or older, recently graduated from a nursing school, registered as a nurse, employed at the participating site, able to converse, read and write in Chinese and willing to complete all study procedures. Graduate nurses allocated to work in the out-patient department (OPD), psychiatric wards and operation rooms (OR) were excluded from the study.

Intervention

The mobile phone application consisted of four modules with video clips that aimed to address CVC-related issues for hospitalized patients. Video content was conceptualized from best available evidence for central-line policy/procedures, a review of the literature and clinical experiences of the team. Feasibility and face validity of each video was determined by consulting two senior clinicians with expertise in CVC assessment and care. During development of the learning materials and platform layouts android app devices providing flexibility and ease-of-use were selected and the navigation structure and environment configuration was planned by the researchers (XLH & YT). Construction of the environment for downloading the mobile app from the internet and installing it on a mobile device was created. Participants could select any module to view and answer associated test questions in the playlist. Content and duration of the modules were: preparation and assessment of CVC tip placement (6 minutes 54 seconds); monitoring central venous pressure (CVP) (1 minute 20 seconds); processes of CVC care (6 minutes 59 seconds); and changing CVC dressings (3 minutes 15 seconds) (Figure 2). Frequency and duration of access were automatically recorded by the app (as shown in Figure 3).

The control condition consisted of routine instructional practices (e.g., provision of reading materials, incidental bedside teaching and/or access to the "Elsevier NursingConnect-Skill" computer-based resource (http://www.nursingconnect.tw) on a traditional, non-portable audio-visual (AV) player accessible through library services.

Validity, reliability and rigor

Knowledge of CVC care

Knowledge of CVC care was assessed by a validated 10-item questionnaire. Items were constructed from a review of the literature. An expert panel (2 academic scholars and 4 critical care specialists) provided an independent and unbiased review. The content validity index (CVI) was .98 for the knowledge questions, indicating adequate content validity. Insightful critique and feedback from the expert panel were used to amend the items before administration. There are four multiple-choice options per question of ##to ## (see appendix ##). A score of 10 points is given to each correct answer. Total scores range from 0-100, where higher scores reflect more knowledge of CVC-related procedures.

Performance of CVC care

Direct Observation of Procedural Skills (DOPS) is a commonly used workplace-based assessment tool originally developed by the Royal College of Physicians (Wragg, Wade, Fuller, Cowan, & Mills, 2003). Subsequent revisions by other groups produced an 11-item assessment that uses a nine-point rating scale with anchors of 1 “a very little extent” - 9 “a very large extent” (Watson et al., 2014). If assessors have not observed or are unable to comment on any item, the form is marked as “unable to comment; U/C”. Scores can be grouped into three categories relating to level of competence and need for supervision: “significant input required from assessor” (scores 1 - 3); “some guidance provided from assessor” (scores 4 6); and “able to manage independently” (scores 7 9) (Chuan, et al., 2016).

A recent systematic review of studies using DOPS reported acceptable reliability and content validity, high satisfaction scores by students and significantly improved student learning (Erfani Khanghahi, & Ebadi Fard Azarg, 2018). In the current study, assessors evaluated participants’ CVC care using the DOPS scale and gave immediate feedback. Item responses were summed to give a total score ranging from 11 - 99, where higher scores indicate competency.

Demographic and clinical details

Participants completed a demographic form asking about age, gender, educational attainment, allocated clinical area, any previous education on CVC care and frequency of watching related materials on the internet during induction.

Randomization and Data Collection

On Day 3 of Week 1 of the induction program, all graduate nurses were informed about the study both verbally and in writing and attended a 50-minute lecture on CVC care. On Day 5 all graduates completed a pen and paper knowledge test on CVC placement and care (Time 1). At the commencement of Week 2, those graduates providing written informed consent to participate in the study were randomly allocated to the experimental (A) or control (B) group (as shown in Figure 1). Randomization was based on a computer-generated code number for two treatment groups of 40 individuals each. Concealment of the treatment allocation from teaching staff, clinical raters and researchers analyzing data was carried out throughout the entire study.

Graduate nurses in the intervention group (n = 41) received security codes to log into the website. Participants were encouraged to view the mobile-based video clips throughout the week. Control participants (n = 41) received written guidelines and told about the library resources.

The written knowledge test was administered again to all graduates after the induction program (Time 2). In a simulated learning environment, clinical skills were measured using adult-sized manikins. Both groups participated in the same evaluation with performance assessed by DOPS and scored by three trained raters. Assessment of inter-rater reliability revealed a mean Cohen's kappa coefficient of .96 prior to the actual study. Raters were blind to graduates' group allocation and unaware of the specific purpose of the current study. Participants demonstrated hand hygiene, use of sterile gloves, exit-site care and dressing changes, measuring central venous pressure (CVP), CVP-guided therapy and strategies for seeking assistance from and interacting with the patient. Data collection occurred from 1 August 2019 – 31 October 2019.

Data analysis

Descriptive statistics were conducted using mean and standard deviations (SD) for continuous data and frequency and percentage for categorical data. Chi-square and independent t-test were used to compare demographic and clinical characteristics between groups at baseline (pretest Time 1). Intention to treat was applied. Within-group changes on knowledge and skill measures were assessed using repeated measures paired t-test. Statistical analyses were performed using SPSS, version 22.0 for Windows with significance level set at $p < 0.05$ (two-tailed) in all cases, with 95% confidence interval reported.

Ethical considerations

Knowledge and skills on CVC care are important in the clinical environment. As such all graduates attended the lecture and completed the baseline knowledge questionnaire during their induction program. Participants then undertook further learning, repeated the knowledge test (Time 2) and were assessed for clinical competence using DOPS after their induction program. Only data from consenting participants was analysed. Participants could request to withdraw their data from the study at any time without penalty. Institutional Human Research Ethics approval was obtained (IRB108-07-B). Anonymity, privacy, confidentiality, and data protection were maintained throughout the study.

Results

Participant Characteristics

Eighty-two graduate nurses provided consent to participate in the study. During the two-week induction program, three dropped out because of transfer to an excluded practice area or other reason. Mean age of participants was 21.75 years (SD 1.48) and most were female. Around half of the participants (51.9%; n = 41) possessed an associate degree and 48.1% (n = 38) had a college or university degree. Graduates worked in emergency and/or intensive care units (38%); medical units (36.7%) or surgical units (25.3%). Around half (50.6%) reported being taught CVC care more than 6 months ago. There were no statistically significant differences between groups on demographic and descriptive characteristics (Table 1).

Effects of mobile-based application on learning

At Time 1 the mean CVC knowledge score was 76.6 (SD 15.6) for the intervention group and 70.5 (SD 15.4) for the control group. Although the initial test-score was slightly better in the intervention group there was no significant difference between groups ($t = 1.76$; $p = .08$). At Time 2 there was a significant increase in knowledge for the intervention group (mean = 93.3, $p <.001$) and a decline in knowledge for controls (mean = 65.3, $p <.001$). The between group difference was significant ($t = -7.98$; $p < .001$, CI = 20.9 ~ 34.8) (Table 2).

Regarding DOPS scores, intervention participants achieved significantly higher mean scores (33.25; SD 5.7) than those in the control condition (29.37; SD 6.4) ($t = 2.83$, $p =.006$, CI= 1.14 ~6.61) after one week. Seven of the 11 DOPS items showed statistically significant differences between nurses exposed to the mobile-based application and controls. Examination of individual DOPS items revealed that graduates in the intervention group had moderate-to-slight degree of competency with scores above 3.5 being more common. In particular, graduates in the intervention group were more likely to obtain informed consent ($t = 2.22$, $p = 0.02$), have appropriate pre-procedure preparation ($t = 2.29$, $p = 0.02$), aseptic technique ($t = 3.68$, $p <.001$), technical ability to perform the skill safely ($t = 2.04$, $p = 0.04$), post procedure management ($t = 2.40$, $p < 0.01$), consideration of the patient ($t = 1.95$, $p < 0.05$) and overall ability to perform the procedure ($t = 2.35$, $p = 0.02$) (Table 3).

Amongst nurses in the intervention group, those who used the app more frequently were more likely to have higher knowledge ($r = .39$, $p = .02$, CI = .11 ~ .99) and DOPS scores ($r = .42$, $p = .008$ CI= .17 ~ 1.03) than those using the app less frequently (less than 2 times within the 7 days) (Table 4).

Discussion

The present study showed the effectiveness of a mobile phone app on graduate nurses' knowledge and skills in caring for patients with CVC placements. The results are novel for graduate nurses and consistent with those of an earlier review that found an increase in medical science students' theoretical knowledge and confidence in performing selected clinical skills after receiving mobile-phone based education interventions (Koohestani, Soltani Arabshahi, Fata, & Ahmadi, 2018). Smartphones have become an integral part of daily life, social relations and patterns of communication. In the current study all participants were smartphone users and familiar with digital technology. As such, they did not report any difficulties accessing and using materials from their own mobile phone devices. The ease of use may explain why many participating graduates used the app resources frequently.

All graduates attended a standard lecture on CVC care and two days later achieved a knowledge score mean of 73.5 out of a possible 100. This result failed to meet the educators' original expectations of graduates' knowledge levels. Such a phenomenon is not surprising given normal, gradual decreases in knowledge retention over time, unless the information/learning is consciously reviewed or used. According to recent studies testing the Ebbinghaus Curve (1885) if there is no reinforcement of new learning, recipients will forget approximately 40 percent over the first 24 hours and 60 percent over 48 hours (Murre & Dros, 2015). Furthermore, Ebbinghaus also proposed that distributed practice is better than intense practice for acquiring and retaining significant information/skills. It is therefore beneficial to spread learning over several days than all at once (Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006). In the current study, participants in intervention group who used the mobile learning app frequently over a week were more likely to be competent and confident in performing the practical skill. Our results echo those of previous studies indicating that simply revising content at regular intervals is associated with easier recall and better performance (Murre & Dros, 2015).

Graduates in the intervention group had significantly better performance on seven of the 11 DOPS items compared with their counterparts. Recent findings have outlined that good aseptic technique and safe peri-procedural management are essential for preventing and arresting the development of iatrogenic infection. For example, Van der Kooi and colleagues (2018) tested the effectiveness of a (1) CVC insertion strategy; (2) WHO-based hand hygiene promotion strategy; or (3) a combination of both to prevent CVC-related bloodstream infections in 14 Intensive Care Units. All strategies contributed to significant improvement in CVC insertion and reduced infection rates but also highlighted the effectiveness of multi-modal approaches. In the present study, the effect of an introductory lecture followed by the mobile app enabled these graduate nurses to have high knowledge and well-developed skills of a crucial clinical procedure.

Longitudinal follow-up may allow us to determine the extent to which these nurses use mobile-app learning for other procedures and the extent to which the current experience bolstered their confidence when caring for patients with CVC placements as well as other conditions.

The advantages of learning anywhere and anytime have long been important benefits of online education. However, mobile app learning (M-learning) can be easier and more flexible than previous e-learning applications, because there is no demand for a learner to be physically at a personal computer or laptop (Basak, Wotto, & Bélanger, 2018). A study with nursing students found perceived benefits of mobile phone technologies included better access to educational resources, improved knowledge and confidence and reduced anxiety around learning in practice (Mather & Cummings, 2017). Although we did not specifically ask students about their experience of using the CVC app, frequency of use could be a reflection of students' perceptions of value. However, some barriers may hamper the adoption of M-learning in some educational settings. These barriers may arise from poor Wi-Fi connectivity, reduce quality of educational content when presented on a small mobile screen, organizational policies limiting mobile phone use and patient confidentiality issues (Raman, 2015; O'Connor, & Andrews, 2018). Correspondingly, enabling nurse educators to develop, test and release high-quality instructional materials can foster safe and appropriate behavior for graduates when using mobile technology for work-based learning and continuing professional development (Mather & Cummings, 2017).

Limitations

There are several limitations of the study that could be addressed in future studies. Firstly, given the small sample size and single participating site, findings should be considered cautiously until the app is replicated with larger diverse samples and sites by other researchers. The brief study design did not permit us to determine if the effects on knowledge and practice were sustained over time, or whether these effects subsequently improve patient care experiences and health outcomes. Therefore, longitudinal studies are recommended. The knowledge measure was developed for the current study and also needs to be tested in other groups. The application of DOPS with trained assessors and standardized use of rating scale was a valid and reliable approach to measure behavior change of graduate nursing staff. Future research could consider observing practice and patient outcomes under clinical conditions.

Conclusion and implications

Implementation of mobile-phone application technology can be considered a feasible means to proactively provide information and training. The app appeared to be easy to use and contributed to improved graduate nurses' knowledge and practice in CVC care. Developing and applying mobile phone applications for a range of clinical practices is recommended. Concurrently, increased information technology support would improve educators' competencies and prompt their use of information communication technology in classes and the clinical environment. Development of institutional policies regarding communication devices should be undertaken to promote these pedagogical practices.

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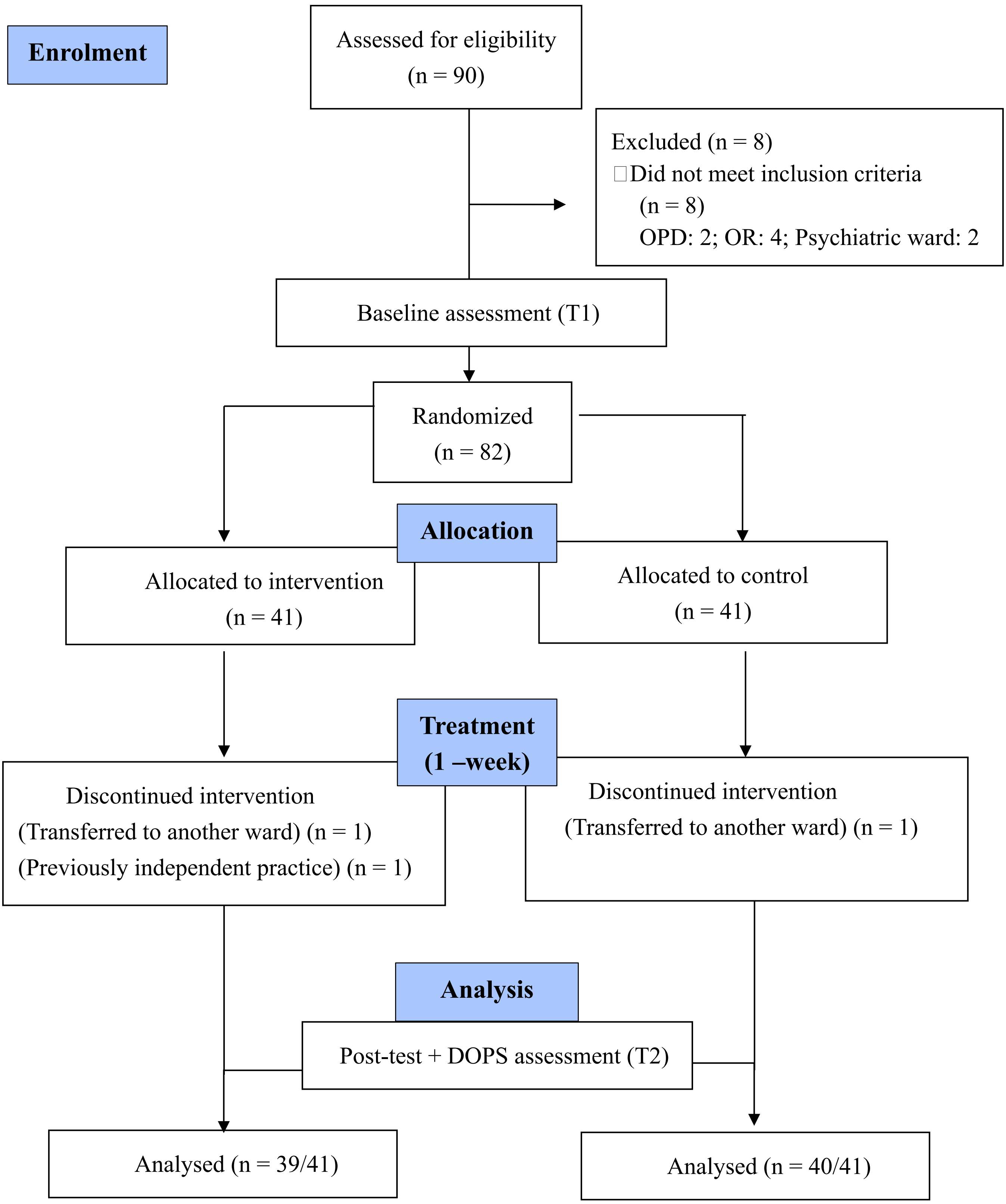

Figure 1: Flowchart of participant recruitment

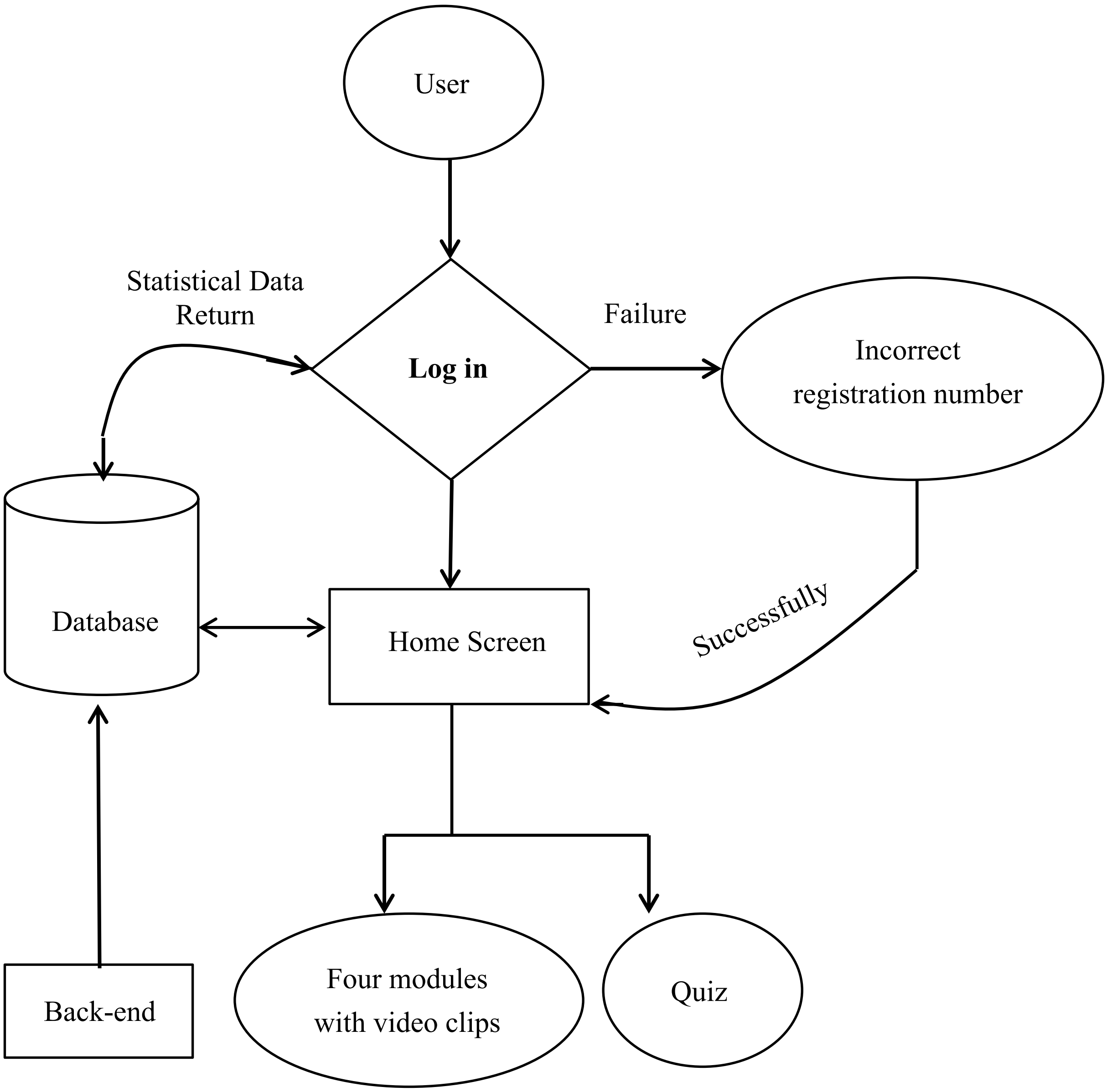

Figure 2: Schematic diagram of the mobile platform application (App)

Menu of options

Entrance mode
(Log-in)

Four video materials

Aseptic technique for CVC dressing changes (1 out of 4)

Figure 3: Screenshots of the mobile platform application (App)

Table 1: Participant characteristics (n = 79)

Variables	Interventional Group A (n = 39) n (%)	Control Group B (n = 40) n (%)	Total (n = 79) n (%)	Statistical analyses X^2	t	p
Age					7.05	0.48
Range	19.9-27.1	20.2-25.7	19.9-27.1			
Mean (SD)	21.6 (1.76)	21.8 (1.16)	21.7 (1.48)			
Gender				0.94		0.33
Female	31 (79.5)	28 (70)	59 (74.7)			
Male	8 (20.5)	12 (30)	20 (25.3)			
Education				4.91		0.16
Associate Degree (5-year Junior)	24 (61.5)	17 (42.5)	41 (51.9)			
Bachelor's Degree						
2-year Senior	1 (2.6)	6 (15)	7 (8.9)			
4-year College	5 (12.8)	6 (15)	11 (13.9)			
University	9 (23.1)	11 (27.5)	20 (25.3)			
Clinical setting				4.27		0.15
Acute and Critical Care	19 (48.7)	11 (27.5)	30 (38)			
Medical wards	12 (30.8)	17 (42.5)	29 (36.7)			
Surgical ward	8 (20.5)	12 (30)	20 (25.3)			
When did they receive the CVC instruction				3.06		0.42
Before half- year	22 (56.4)	17 (42.5)	39 (49.4)			
0.5~1 year ago	4 (10.3)	4 (10)	8 (10.1)			
1~2 years ago	11 (28.2)	13 (32.5)	24 (30.4)			
More than 2 years ago	2 (5.1)	6 (15.0)	8 (10.1)			
Times of performing CVC care in the past year				4.65		0.30
Never	5 (12.8)	9 (22.5)	14 (17.7)			
1~2	27 (69.2)	24 (60)	51 (64.6)			
3~5	5 (12.8)	7 (17.5)	12 (15.2)			
More than 5	2 (5.1)	-	2 (2.5)			
Frequency of watching related materials on the internet during induction				2.63		0.43
Never	24 (61.5)	28 (70)	52 (65.8)			
3 times per week	12 (30.8)	8 (20)	20 (25.3)			
4~5 times per week	2 (5.1)	4 (10)	6 (7.6)			
More than 5	1 (2.6)	-	1 (1.3)			

Table 2: Comparison of correct response by time by groups (N = 79)

	Intervention Group A (n_2 = 39)			Control Group B (n_1 = 40)			Group A vs Group B
	Correct rate (%)		Paired samples (pre-post)	Correct rate (%)		Paired samples (pre-post)	Independent sample (post)
	Pre-test $(T_1)^a$	Post-test (T_2)	t_2	Pre-test $(T_1)^a$	Post-test (T_2)	t_1	t_3
Sum of the knowledge score	**76.6**	**93.3**	-6.57***	**70.5**	**65.3**	1.75	-7.98***
ITT[b] (Sum of the knowledge score)	**76.1**			**70**			
Item 1: Purpose of insertion of a CVC line	76.9	89.7	-1.7	55	65	-1.27	2.70***
Item 2: Indications for central venous access	48.7	87.2	-4.07**	45	55	-1.27	3.32***
Item 3: Contraindications to the use of CVC	74.4	94.9	-2.73**	57.5	47.5	0.78	5.36***
Item 4: Equipment required for CVC insertion	84.6	97.4	-2.36*	85	75	1.27	3.00***
Item 5: Procedure of CVC insertion	76.9	92.3	-1.78	77.5	80	-0.33	1.58
Item 6: Process of CVC care	87.2	100	-2.36*	87.5	80	0.82	3.08***
Item 7: How often the tubing should be changed?	46.2	87.2	-4.02**	42.5	30	1.4	6.24***
Item 8: Daily performance of CVC care	100	100	-	97.5	90	1.35	2.05*
Item 9: Central venous access via a femoral vein	79.5	97.4	-2.88**	77.5	60	2.21*	4.48***
Item 10: Measurement of central venous pressure (CVP)	92.3	87.1	0.81	80	70	1.66	1.87

Statistical significance: *$p < 0.05$; ** $p <.01$; *** $p <.001$

$(T_1)^a$: Mean pretest scores between groups were not statistically different ($t = 1.76$, $p = 0.08$).

ITT[b] (Intention-to-treat): Initially, 41 nurses per group were enrolled and no difference in knowledge ($t = 1.79$, $p = 0.07$).

Table 3: Comparison of DOPS scores by group (n = 79)

	Direct Observation of Procedural Skills (DOPS) item	Intervention Group A (n_2 = 39) T_2	Control Group B (n_1 = 40) T_2	Difference	Independent samples t	p
	Average of sum (SD)	**33.25 (5.7)**	**29.37 (6.4)**	**3.88**	**2.83** *	**0.006**
1	Demonstrates understanding of indications, relevant anatomy, technique of procedure	3.54 (0.7)	3.43 (1.0)	0.11	1.67	0.09
2	Obtains informed consent	4.23 (0.7)	4.05 (1.0)	0.18	2.22*`	0.02
3	Demonstrates appropriate preparation pre-procedure	4.15 (0.8)	3.99 (0.8)	0.16	2.29*	0.02
4	Appropriate analgesia or safe sedation	-	0.10 (0.2)	-0.1	-1.41	0.16
5	Aseptic technique	3.38 (0.7)	3.17 (0.5)	0.21	3.68*	0.00
6	Technical ability to perform skill safety	3.59 (0.8)	3.47 (0.7)	0.12	2.04*	0.04
7	Seeks help where appropriate	0.41 (1.2)	0.29 (0.5)	0.12	1.10	0.27
8	Post procedure management	3.38 (1.2)	3.03 (1.3)	0.35	2.40*	0.01
9	Communication skills	3.38 (0.7)	3.3 (0.9)	0.08	1.49	0.13
10	Consideration of patient/professionalism	3.62 (0.6)	3.52 (0.7)	0.10	1.95*	0.05
11	Overall ability to perform procedure	3.56 (0.6)	3.43(0.8)	0.13	2.35*	0.02

Statistical significant was set at $p < 0.05$

Table 4: Correlations between frequency of use and test scores (knowledge and skill on CVC care) (n = 39)

Variables	n (%)	Range	Knowledge of CVC care [a] Mean (SD)	Spearman's *(p)*	Range	Performance of CVC care [b] Mean (SD)	Spearman's (*p*)
Frequency of use				0.39*` (0.02)			0.42*`*`*` (0.008)
1-2 times	17 (43.5)	60-100	87.65 (12.51)		28-44	31.47 (4.77)	
3-5 times	19 (48.7)	90-100	97.89 (4.19)		28-54	33.68 (5.88)	
6-10 times	2 (5.1)	100	100.00		36-41	38.50 (3.54)	
More than 10 times	1 (2.5)	90	90.00		45	45.00 (none)	

Knowledge of CVC care: measured by 10-item questionnaire

Performance of CVC care: measured by DOPS

CVC: Central venous catheterization

DOPS: Direct Observation of Procedural Skills

Appendix (Table S1): Knowledge of central venous catheter care

Questions	Answers
1. Which of following conditions does NOT require insertion of a central venous catheter (CVC) line?	
a. Monitoring arterial pressure	(a)
b. Monitoring central vein pressure (CVP) to determine the adequacy of circulating blood volume	
c. Infusion of fluids and medication through CVC line	
d. Central vein catheterization for total parenteral nutrition (TPN)	
2. Which is TRUE regarding the indications for central venous access?	
a. Ketoacidosis b. Cerebral infarction	(d)
c. Coronary artery disease d. Hypovolemic shock	
3. Which is NOT a contraindication for CVC use?	
a. Diffuse intravascular coagulation (DIC)	(c)
b. Poor blood coagulation c. Burn injury	
4. Which of following is NOT required to prepare a CVC?	
a. Suture scissors b. Maximal sterile barrier precautions	(a)
c. 2% Xylocaine d. 3.0 surgical suture	
5. Which description about CVC insertion is INCORRECT?	
a. Wear a mask, hair cap, sterile gown and gloves when assisting the physician	
b. Give the physician the largest sterile surface in a sterile manner	(c)
c. Assist the physician to extract Morphine for local anesthesia	
d. Perform catheter care and apply OPsite to the puncture site after CVC insertion by the physician	
6. Which is FALSE regarding CVC care?	
a. Need to wear sterile gloves when caring for the catheter	(c)
b. Daily check of the expiration date on the dressing	
c. Ensure the sterilized area is smaller than the wound dressing	
d. Use an alcohol pad to wipe the front and side of injection (IV) cap for a last 5 seconds	
7. How often should the tubing be changed if bold products, propofol or lipids are administered?	(c)
a. Replace immediately after use b. Within 8 hours	
c. Within 24 hours d. Within 3 days	
8. Which is FALSE regarding daily CVC care?	
a. Assess the skin daily for signs of redness, swelling or discharge	(d)
b. Discuss the need for CVC replacement with a physician	
c. Moisture or fluid leakage must always be evaluated for the need to change the dressing	
d. Change the injection (IV) cap daily	
9. The CVC is placed in a patient's femoral vein. What should be the focus of clinical care by nursing staff?	
a. Assess for infection b. Assess risk of slippage	(a)
c. Aesthetic issues d. Sticky tips	
10. Which is FALSE regarding measurement of central vein pressure (CVP) and the manometer scale?	(d)
a. Air in the CVC line b. Line kinking	
c. Problem with 3-Way stopcock (not open) d. Hypovolemic shock	