Effects of a multi-component educational intervention on nurses' knowledge and adherence to standard precautions in intensive care units

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Shiva Gomarverdi¹, Mahnaz Khatiban^{1,2} , Ali Bikmoradi³
and Ali Reza Soltanian⁴

Abstract

Background: The standard precautions (SPs) should be disseminated and implemented by healthcare providers. This study aimed to examine the effects of a multi-component educational intervention on nurses' knowledge and adherence to the SP guidelines in intensive care units (ICUs).

Methods: This small-scale study consisted of a cluster randomised trial. Two ICUs, located in different hospitals, participated in the study. Nurses ($n = 15$) in one ICU received the multi-component educational intervention. The intervention involved an educational (with multiple instructional media) and a behavioural (with hands-on practice) component. Nurses' knowledge and adherence were assessed at pre-test and two and six weeks after the intervention.

Results: Results showed significant group by time interaction effects for both outcomes: a large improvement was found in the experimental group over time, but not in the control group. The experimental nurses' knowledge improved from 15 ± 2.47 at pre-test to 19 ± 2.65 and 19.53 ± 0.92 at follow-ups. Similarly, their adherence increased from 19.87 ± 4.44 at pre-test to 29.20 ± 5.00 and 28.40 ± 4.37 at two and six weeks post-test, respectively.

Conclusions: The multi-component educational interventions had demonstrated initial effectiveness in enhancing ICU nurses' knowledge and adherence to the SPs guidelines. The intervention is a promising approach for designing effective continuing education initiatives aimed to improve nurses' practice.

Keywords

Education, knowledge, adherence, standard precautions, nurses, intensive care unit

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Introduction

Hospital-acquired infections (HAIs) are the most common complications in hospitalised patients (Huis et al., 2012), particularly in patients admitted to intensive care units (ICUs). HAIs occur in patients in ICUs as high as 51% (Vincent et al., 2009), and increase the rates of morbidity and mortality, as well as the costs of care (Huis et al., 2012). Factors related to patients' characteristics (e.g. compromised immune system) and to healthcare providers' practices (e.g. hand washing) contribute to HAIs. Healthcare-associated infections (HCAIs) are on the rise. According to the World Health Organization (WHO), 7.1

¹Student Research Center, School of Nursing and Midwifery, Hamadan University of Medical Sciences, Hamadan, Iran

²Mother & Child Care Research Center, Department of Medical Surgical Nursing, School of Nursing and Midwifery, Hamadan University of Medical Sciences, Hamadan, Iran

³Department of Health Economics and Management, School of Public Health, Hamadan University of Medical Sciences, Hamadan, Iran

⁴Modeling of Noncommunicable Disease Research Center, Department of Biostatistics and Epidemiology, School of Public Health, Hamadan University of Medical Sciences, Hamadan, Iran

Corresponding author:

Mahnaz Khatiban, Mother & Child Care Research Center, Department of Medical Surgical Nursing, School of Nursing and Midwifery, Hamadan University of Medical Sciences, Hamadan, Iran.

Email: mahnaz.khatiban@gmail.com

million cases of HAIs and 99,000 deaths linked to HAIs are reported every year, worldwide, incurring nearly \$32 million in the United States alone (Cardo et al., 2010). In developed countries, HAIs affect 3.5–12% of patients (Allegranzi et al., 2011).

The WHO and the Centers for Disease Control and Prevention (CDC) developed Standard Precautions (SP) as practical guidelines for hand washing, alcohol-based hand-rubbing, wearing gloves, wearing protective equipment and disposing of sharp objects. Healthcare providers are expected to gain sufficient knowledge, acquire the necessary skills and adhere to the SP in order to reduce the risk of HAIs for patients and to protect themselves from infections (Pyrek, 2018; Siegel et al., 2007). Today, the goal of the Safety Challenge is to confirm that infection control is accredited and improved among healthcare workers to support the reduction of HAIs and their consequences (Bebell and Muir, 2014). Although the SP guidelines were published a decade ago, the results of studies conducted in several countries indicate that healthcare providers have poor knowledge of infection control and less than optimal adherence to the SP guidelines. For instance, knowledge of sources and methods of infection transmission and of strategies to control for infection was reported to be inadequate among healthcare workers in Ethiopia (Tenna et al., 2013), medical and nursing students in Italy (D'Alessandro et al., 2014), medical students in Saudi Arabia (Amin et al., 2013) and radiographers in Jordan (Abdelrahman et al., 2017). The rate of adherence to SP was 57.4% among 260 nurses in Hong Kong and 69.4% among 560 nurses in Brazil (Pereira et al., 2015). Both Italian nurses and physicians had low adherence concerning standard precautions (Parmeggiani et al., 2010).

Educational interventions have been designed to inform healthcare providers of the SP guidelines and to improve their adherence to SP in practice. The evaluation of these interventions supported their effectiveness in improving students' and healthcare providers' knowledge, attitudes and adherence to SP, as well as in reducing the rates of HAIs and related complications, patient length of stay and costs of care (Al-Hussami and Darawad, 2013; Bikmoradi et al., 2013; Holmen et al., 2016; Huskins et al., 2011; Jansson et al., 2013; Xiong et al., 2017). The improvement in these outcomes, however, was of a moderate size, suggesting that there is room for improvement. We designed a multi-component educational intervention and offered it as a continuing education initiative, to train nurses in implementing the SP guidelines in ICUs. The intervention design was informed by evidence supporting the need to integrate a range of teaching strategies (didactic and hands-on practice) and instructional media (e.g. video presentation, group discussion) (Jansson et al., 2016; Rosenthal et al., 2012; Stock et al., 2016; Xiong et al., 2017) in order to meet different learning styles and optimise the effectiveness of the intervention in changing practice. Accordingly, the intervention consists of an educational component and a

behavioural component. The aim of this small-scale study was to examine the effects of the multi-component educational intervention on nurses' knowledge and adherence to the SP guidelines, in ICUs.

Methods

A cluster randomised trial was used in this small-scale study. This design was appropriate to generate an experimental group of nurses exposed to the multi-component educational interventions and a control group of nurses who received no education while minimising the risk of contamination.

Two ICUs in two different hospitals were selected. The two ICUs were comparable on several characteristics: both were teaching hospitals, affiliated with Hamadan University of Medical Sciences; admitted patients with similar medical conditions and acuity levels to the ICUs; and had a similar nursing staff mix. The ICUs were randomly allocated to the experimental or the control groups (Figure 1). The nurses in both groups were comparable in their demographic and professional characteristics (Table 1). The outcomes of knowledge and adherence to the SP guidelines were measured at pre-test and at two and six weeks after the intervention. The study was conducted between October 2012 and August 2013.

The study was approved and confirmed by the Vice-Chancellor of Technology and Research at the Hamadan University of Medical Sciences, Research Ethics Committee (ethical approval code: 9110193768) and Iranian Registry of Clinical Trials (IRCT2012082810686N1). Required permissions were also obtained from the authorities of both hospitals. All nurses who were willing to participate in the study signed the written consent forms after explaining the study aims and process.

The target population included nurses working in the selected ICUs. Nurses were included if they graduated from a university program (Bachelor of Science and/or a Master of Science) in nursing, with one or more years of experience working in an ICU. With the conventional sampling method, a total of 30 nurses, 15 in each of the experimental and the control groups, met the inclusion criteria. This sample size was adequate for this small-scale study, providing statistical power to detect moderate differences in the outcomes between the two groups and over the three points in time (Hertzog, 2008).

Nurses in the control group were not exposed to any educational resources related to the SP guidelines during the study period, whereas nurses in the experimental group received the multi-component educational intervention. A PhD-prepared nurse educator who led the development of the intervention provided the intervention in three 2-h sessions, offered on three consecutive days. The intervention was given in small ($n = 7$ or 8) groups to promote nurses' engagement in the discussion and to facilitate the hands-on

Table 1. Nurses' demographic and professional characteristics.

Variables	Control group (n = 15)	Experiment group (n = 15)	P value*
Age (years) (mean $\pm$ SD)	30.87 $\pm$ 3.1	30.27 $\pm$ 3.9	0.643
Work experience (years) (mean $\pm$ SD)	7.51 $\pm$ 3.3	5.87 $\pm$ 3.4	0.189
Marital status (n (%))			0.464
Single	8 (53.3)	6 (40.0)	
Married	7 (46.7)	9 (60.0)	
Nursing degree (n (%))			0.232
Bachelors	15 (100.0)	13 (86.7)	
Masters	0 (0.0)	2 (13.3)	
Previous training in the Standard Precautions (n (%))			
Yes	12 (80.0)	9 (60.0)	0.427
No	3 (20.0)	6 (40.0)	

*Chi-Square test and t-test.
SD, standard deviation.

training in the implementation of the SP procedures. The education component covered information about the prevalence, transmission routes and impact of HAIs; the importance of preventing HAIs to reduce the burden of complications for patients and nurses; and the SP guidelines related to the procedures for hand washing, alcohol-based hand rubbing, wearing gloves, wearing protective equipment and disposing of sharp objects like needles. Different teaching strategies were used to deliver the information: lecture with the PowerPoint presentation followed by a question and answer session; video presentation to show how the SP procedures are correctly implemented; and small group discussion to clarify the SP procedures. The behavioural component involved a demonstration of each SP procedure, followed by supervised practice of the procedure by each nurse attending the session, feedback on individual nurse's performance and a group discussion of potential issues with the implementation of the SP procedures in practice. To reinforce the implementation of the SP procedures in practice, visual displays, (e.g. coloured posters and photos) were mounted in different locations in the ICU (e.g. nursing station, wash basins) and written materials (e.g. PowerPoint slide presentation, education pamphlets) were uploaded on the ward computers for review as needed.

For study instruments, standard questions were used to assess nurses' demographic characteristics (age, gender, marital status) and professional qualifications (nursing degree, work experience, previous SP training) at pre-test. Since no previously validated instruments were found, the investigators developed a questionnaire to measure knowledge of the SP guidelines and a checklist to evaluate adherence to the SP procedures. The two instruments were

developed according to the WHO and CDC guidelines (CDC, 2016; WHO, 2002). The content of the questionnaire and checklist was based on the published SP guidelines. The face and content validity of both instruments were confirmed by 10 nursing experts and educators, evidenced by a content validity ratio (CVR) of 70, indicating the items were relevant and necessary in this research context.

The knowledge questionnaire had 21 items, including multiple-choice and true/false questions, related to hand washing and alcohol-based hand rub, wearing gloves and protective equipment and disposing of sharp objects. The response options were rated as 1 (i.e. correct) or 0 (i.e. incorrect). The total score, computed as the sum of the items' scores, was in the range of 0–21, with high scores reflecting high knowledge levels. The reliability of knowledge questionnaire was determined by a test–retest with a two-week interval and internal consistency. The Pearson correlation ($r = 0.83$, $P < 0.001$) and the Kuder-Richardson (KR) coefficient (0.75) were high.

The checklist contained 53 items capturing the five SP procedures: hand washing (14 items); alcohol-based hand rub (9 items); wearing gloves (14 items); wearing protective equipment as face mask, face shield, apron or disposal gown (11 items); and disposing of sharp objects (5 items). The checklist was completed by observers and rated as 0 (i.e. the nurse does not adhere) or 1 (i.e. nurse adheres). A total score is computed for each of the five SP procedures and for all items, with higher scores quantifying high levels of adherence. The checklist demonstrated good test–retest reliability (KR coefficient = 0.71).

All data were collected at the same three points in time: pre-test (T0); two weeks post-test (T1); and six weeks

Table 2. Mean scores on knowledge and adherence to the SP in the experimental and control groups.

	Mean (95% CI)		P value (t-test)	P value (RMANOVA)
Variable	Control group (n = 15)	Experiment group (n = 15)		
Knowledge (0–21)				
T0	14.53 (13.26–15.80)	15.60 (14.35–16.85)	0.253	< 0.001
T1	15.47 (14.29–16.65)	19.00 (17.67–20.33)	< 0.001	
T2	14.60 (13.50–15.69)	19.53 (19.06–20.00)	< 0.001	
Adherence (0–53)				
T0	21.00 (19.05–22.94)	19.87 (17.62–22.12)	0.461	< 0.001
T1	21.47 (19.19–23.74)	29.20 (26.67–31.73)	< 0.001	
T2	21.47 (19.37–23.57)	28.40 (26.20–30.59)	< 0.001	

RMANOVA, repeated measures analysis of variance

post-test (T2) in both the experimental and the control groups. Eligible, consenting nurses were asked to complete the knowledge questionnaire in a private room available in the ICU, in advance of the shift during which their adherence to the SP procedures was assessed. To reduce the Hawthorne effect during observation, the first set of observations were discarded, while participants become familiar with being observed. The subsequent completed checklists were used for the data analyses. To minimise researcher bias, two external observers were trained in the use of the adherence to SP checklist. On the shift selected for observation, the observers shadowed the participating nurses and chose the time of the observation randomly. They recorded whether the nurse performed the SP procedures as described in the checklist, independently. The inter-rater agreement was estimated by 10 simultaneously completed checklists. The Chi-square test showed no significant differences between scores of the two external observers ($P > 0.05$).

The collected data were analysed using SPSS-13 (SPSS, Inc., Chicago, IL, USA). Descriptive statistics (frequency distribution, mean and standard deviation) were performed on all variables. The demographic characteristics of the two groups were compared using the Chi-square test (for categorical variables) and the independent sample t-test (for continuous variables). To compare the outcomes between the two groups over time, a repeated measure analysis of variance (RMANOVA), followed by post-hoc independent sample and paired t-tests were used. All analyses were performed at 95% confidential intervals.

Results

At pre-test, nurses in both the experimental and control groups were similar in terms of their demographic and professional characteristics (Table 1). All nurses were women. On average, they were young, married adults. The majority had a Baccalaureate of Science degree in nursing, with < 10

years of work experience. Most indicated they had previous training in SP as a hospital-based re-education program.

Table 2 shows the mean scores for knowledge and adherence to SPs in the experimental and control groups at pre-test (T0), two weeks post-test (T1) and six weeks post-test (T2). At pre-test, nurses in the experimental and control groups had the same level of knowledge ($P > 0.05$). The results of RMANOVA indicated a significant group by time interaction effect. There was an ascending trend in experimental nurses' knowledge of SPs in over the three times of measurement ($P < 0.001$). No significant change in knowledge was found in the control group over time ($P > 0.05$).

At pre-test, nurses in the experimental and control groups had the same level of adherence to the SPs ($P > 0.05$). The RMANOVA findings showed a significant group by time interaction effect. The mean scores on adherence to SPs in the experimental group improved over the three times of measurement; two weeks ($P < 0.001$) and six weeks post-intervention ($P < 0.001$). The mean level of adherence did not change in the control group at T1 and T2 ($P > 0.05$).

In addition to overall adherence, we examined the effects of the educational intervention on the five SP procedures. The results are in Table 3. At pre-test, nurses in the experimental and control groups had comparable mean scores on the five SP procedures (all P s > 0.05). The results of the RMANOVA showed a significantly ascending trend in the experimental group's adherence to the hand washing ($P < 0.001$), alcohol-based hand rubbing ($P < 0.05$) and disposing of sharp objects ($P < 0.01$). There was no significant change in the mean scores of the control group on any of the SP procedures ($P > 0.05$).

Discussion

The results of this small-scale study showed that the multi-component educational intervention significantly improved nurses' knowledge and adherence to SP. Our findings are

Table 3. Mean scores on adherence to the SP procedures in the experimental and control groups.

Variable	Mean (95% CI)		P value (t-test)	P value (RMANOVA)
	Control group (n = 15)	Experiment group (n = 15)		
Hand washing (0–14)				< 0.001
T0	6.13 (5.42–6.84)	5.47 (4.76–6.18)	0.205	
T1	6.20 (5.61–6.79)	8.27 (7.54–8.99)	< 0.001	
T2	5.93 (4.97–6.89)	8.07 (7.27–8.87)	0.002	
Alcohol-based hand rubbing (0–9)				
T0	3.40 (2.59,4.20)	2.93 (2.17–3.69)	0.421	0.044
T1	2.93 (2.20,3.66)	4.40 (3.87–4.93)	0.005	
T2	2.93 (2.20,3.66)	4.40 (3.87–4.93)	0.005	
Wearing gloves (0–14)				0.058
T0	6.00 (5.58–6.41)	6.20 (5.22–7.18)	0.722	
T1	6.13 (5.30–6.95)	8.07 (7.15–8.99)	0.005	
T2	6.13 (5.35–6.91)	7.73 (6.69–8.77)	0.023	
Wearing protective equipment (0–11)				0.606
T0	4.33 (2.62–6.03)	3.87 (2.15–5.59)	0.710	
T1	4.33 (2.49–6.17)	5.40 (3.66–7.14)	0.416	
T2	4.13 (2.23–6.03)	5.27 (3.49–7.05)	0.400	
Disposing of sharp objects (0–5)				0.003
T0	1.53 (1.02–2.03)	1.40 (0.79–2.01)	0.740	
T1	1.87 (1.36–2.38)	3.07 (2.62–3.52)	0.002	
T2	1.87 (1.36–2.38)	3.07 (2.62–3.52)	0.002	

RMANOVA, repeated measures analysis of variance

consistent with those of previous studies (Al-Hussami and Darawad, 2013; Bikmoradi et al., 2013; Holmen et al., 2016; Huskins et al., 2011; Jansson et al., 2013; Nour-Eldein and Mohamed, 2016; Shrestha, 2015; Xiong et al., 2017) in supporting the benefits of education, using multiple teach strategies and instructional media, in positively changing nurses' knowledge of HAI and performance and adherence to standards for preventing infections.

Educational interventions are designed to address the association between knowledge and practice. A significant relationship was found between nurses' knowledge of infection control and adherence to standard precautions (Luo et al., 2010). It had also been shown that healthcare providers with low knowledge about the prevention of central venous catheter-related infection have low adherence to the standard guidelines of central venous catheter care (Alkubati et al., 2015). The results of a web-based survey suggested a weak relationship between nurses' knowledge and practice of SP (OM and Tubaishat, 2015). Education is expected to increase knowledge, which in turn informs

changes in practice. To effect changes in practice, educational interventions should include, in addition to various instructional media, a behavioural component focusing on hands-on training in the skills required for practice, as implied by the findings of this small-scale study and previous ones. A single educational intervention comprising simulation only, to the exclusion of feedback and retraining opportunities, was not effective in improving critical care nurses' adherence to current hand hygiene guidelines at the targeted behaviour rates (Jansson et al., 2016). According to an Iranian study, an educational intervention based on the health belief model (HBM) was able to improve nurses' knowledge, perceived threat and perceived benefits by reducing perceived barriers and improving the control of nosocomial infections among nurses (Zeigheimat et al., 2016). Interactive training in small groups was found to have a significant effect on nurses' adherence to hand hygiene (Stock et al., 2016). A short-term evidence-based education improved ICU nurses' knowledge, attitude and adherence of hand washing as a preventive strategy

Figure 1. Trial profile.

to ventilator-related pneumonia (Huskins et al., 2011). A multidimensional approach to education was found useful in reducing ventilator-associated pneumonia rate by 31% (Rosenthal et al., 2012).

Our study's findings indicated that the multi-component educational intervention was not successful in increasing the average score on adherence to wearing protective equipment (face mask, face shield, apron or disposal gown). This finding is consistent with that of a study conducted in China; the mean score on adherence to the use of protective equipment was the lowest among the SP procedures (Luo et al., 2010). The exact reason for low adherence to use of protective equipment could not be elucidated and requires further investigation. It is possible that nurses find the protective equipment uncomfortable or challenging to use when providing patient care.

The multi-component educational intervention and the repeated measure design are strengths of our study. The intervention targeted nurses' knowledge and skills, and was given in three sessions; it is a promising intervention that can be offered as ongoing education. The repeated measure design was helpful in detecting the time at which changes in the outcomes took place, and whether the changes were maintained and retained over time. It can therefore be helpful in reducing the main concern about health promotion programs which is the sustainability of the outcomes of the health promotion programs in the long term (Swerssen and Crisp, 2004).

The small sample size and the potential differences in cultural aspects for each of the ICU settings are limitations of our study; future research is required to determine if the

findings may be applicable to nurses working in other types of units. The short term of our education program intervention can be considered as a strong point, but the long-term education programs with follow-up studies are advised. Although the knowledge questionnaire and the adherence checklist were content valid and reliable, further testing of their psychometric properties is needed.

Conclusion

In conclusion, the multi-component educational intervention was effective in improving ICU nurses' knowledge and overall adherence to the standards precautions. Additional work is required to determine factors that may have influenced nurses' adherence to one SP procedure that is, wearing protective equipment (face mask, face shield, apron or disposal gown). The intervention is feasible and effective and could be recommended as a continuing education intervention for use with nursing staff working in other hospital units.

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ORCID iD

Mahnaz Khatiban <https://orcid.org/0000-0002-7060-2205>

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Supplementary material

Data supporting this study are stored by the corresponding author and will be accessed if requested.

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