RESEARCH ARTICLE

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Analysis of the Efficiency and Cost of a Care Bundle for Prevention of Common Infections in an Intensive Care Unit: A Quasi-Experimental Pretest-Posttest Design Study

ABSTRACT

Objective: Healthcare-associated infections, threaten patient safety, cause prolonged hospitalization, morbidity, mortality and increased costs. This study was conducted to evaluate the effectiveness of interventions to prevent healthcare-associated infections and the effect of these interventions on cost.

Methods: A quasi-experimental pretest-posttest design study was completed between 1 January and 30 June 2018, and 1 October 2018 and 31 March 2019, in an intensive care unit, with a total of 54 patients, 27 pre-training and 27 post-training.

Results: In the study, infection rates were 20.34 in January to March 2018, 25.7 in April to June 2018, 20.97 in October to December 2018 and 17.77 in January to March 2019. When the infection rates of the four different periods were compared, it was found that there was a decrease compared to the pre-training period but that this decrease was not statistically significant (p>0.05). The average cost before the training was 11361.35₺ and the average cost after the training was 9149.87₺. Average bed costs, which are the most important of all costs, decreased by 25.7% compared to pre-training at the 95% confidence interval (5241.86₺-13251.50₺ and 3489.03₺-10257.41₺, respectively).

Conclusions: In conclusion, the study determined that training provided a significant increase in the intensive care nurses' scores related to healthcare-associated infections and there were decreases in healthcare-associated infection rates, lengths of hospital stay and cost after the training although these were not statistically significant.

Keywords: Healthcare-Associated Infections, Care Bundle, Nursing, Cost.

Bir Yoğun Bakım Ünitesinde Sık Görülen Enfeksiyonların Önlenmesi İçin Bir Bakım Paketinin Etkinlik Ve Maliyetinin Analizi: Yarı Deneysel Bir Öntest-Sontest Tasarım Çalışması

ÖZET

Amaç: Sağlık hizmeti ilişkili enfeksiyonlar hasta güvenliğini tehdit etmekte, hastanede yatış süresinin uzamasına, morbidite, mortalite ve maliyetlerin artmasına neden olmaktadır. Bu çalışma, sağlık hizmeti ilişkili enfeksiyonları önlemeye yönelik müdahalelerin etkinliğini ve bu müdahalelerin maliyete etkisini değerlendirmek amacıyla yapılmıştır.

Gereç ve Yöntem: Bu araştırma bir yoğun bakım ünitesinde 1 Ocak – 30 Haziran 2018 ile 1 Ekim 2018 – 31 Mart 2019 tarihleri arasında 27 eğitim öncesi ve 27 eğitim sonrası olmak üzere toplam 54 hasta ile yarı deneysel ön test-son test tasarım çalışması olarak yapılmıştır.

Bulgular: Çalışmada enfeksiyon oranları Ocak-Mart 2018'de 20.34, Nisan-Haziran 2018'de 25.7, Ekim-Aralık 2018'de 20.97 ve Ocak-Mart 2019'da 17.77 olarak bulunmuştur. Dört farklı dönemin enfeksiyon oranları karşılaştırıldığında, eğitim öncesine göre eğitim sonrasında enfeksiyon oranlarında azalma olduğu ancak bu düşüşün istatistiksel olarak anlamlı olmadığı saptanmıştır (p>0.05). Eğitim öncesi ortalama maliyet 11361.35₺, eğitim sonrası ortalama maliyet 9149.87₺ olarak belirlenmiştir. Tüm maliyetlerin en önemlisi olan ortalama yatak maliyeti eğitim öncesine göre %95 güven aralığında %25,7 oranında azalmıştır. (5241.86₺-13251.50₺, sırasıyla 3489.03₺-10257.41₺).

Sonuç: Sonuç olarak, çalışmada eğitimin yoğun bakım hemşirelerinin sağlık hizmeti ilişkili enfeksiyonlara ilişkin puanlarında anlamlı bir artış sağladığı, sağlık hizmeti ilişkili enfeksiyon oranlarında, hastanede kalış sürelerinde ve eğitim sonrası maliyette istatistiksel olarak anlamlı olmasa da azalma sağladığı belirlenmiştir.

Anahtar Kelimeler: Sağlık Hizmeti İlişkili Enfeksiyonlar, Bakım Paketi, Hemşirelik, Maliyet.

INTRODUCTION

Healthcare-associated infections (HCAIs), which are an important health problem, are accepted as the most important indicators of the quality of care in hospitals. The most common HCAIs in the intensive care unit (ICU) are catheter-associated urinary tract infection (CA-UTI), ventilator-associated pneumonia (VAP) and catheter-associated bloodstream infection (CA-BSI) (1). Healthcare infections increase morbidity, mortality, long-term disability, hospital stay, microbial resistance to antibiotics, and healthcare costs (2,3).

HCAI prevention and control is very complex and multidimensional approaches and strategies such as hand hygiene, surveillance, cohort studies and patient safety are required to address this important issue (4). Patient safety is an important topic, and this includes infection control. By integrating infection control programs with quality improvement programs in hospitals, HCAI rates can be monitored and the attempt can be made to prevent in-hospital spread (5). Studies on the prevention of the HCAIs show that it is possible to achieve the goal of zero nosocomial infections with the implementation of a bundle of proven interventions to prevent a specific nosocomial infection (6,7). According to the evidence from these studies, it is necessary to integrate care bundles for intensive care patients. In cases where compliance is kept at a high level, in particular, the effectiveness of care bundles increases and causes a significant decrease in mortality and morbidity (7-10).

HCAI’s have considerable economic impact on health care services and the cost of national health care. Infections require increased treatment costs (for example drug therapy and procedures), involve increasing numbers of laboratory and diagnostic investigations and delay patient discharge. So investment in infection prevention and control is therefore highly cost-effective (10). Studies have shown that with the use of care bundles prepared based on the parameters in the guidelines, HCAIs decrease or can even be prevented (3,11-13). In this case, the prevention or even elimination of HCAIs means a decrease in costs. In a study investigating the cost effect of the hand hygiene compliance program in the ICU, it was concluded that the cost increased 2.5 times in patients with HCAIs compared to those without (14). In another study, in which a hospital cleaning bundle was applied to reduce HCAIs, it was determined that the application of a cleaning bundle provided cost savings of Australian dollars 147 500 (15). From this point of view, this study aimed to determine the effect of using care bundles in the prevention of HCAIs on infection rates as well as determining the effect on costs. In Turkey, this study is the first to study three important issues and costs of HCAIs. In addition, it will also contribute to the literature on the prevention of HCAIs.

MATERIAL AND METHODS

Study Design: The research was a quasi-experimental pretest-posttest study conducted to evaluate the effectiveness of interventions to prevent HCAIs and the effect of these interventions on cost.

Study Setting: The study was conducted at a state university hospital in Turkey in four stages: between 1 January and 30 June 2018; 1 October 2018 and 31 March 2019 (the study was interrupted for three months between 1 July 2018 and 30 September 2018 because it coincided with the annual leave period of the nurses). The research was conducted in the chest diseases ICU of the hospital. The chest unit provides services with a seven-bed capacity and a total of 14 nurses, two assistant doctors and two faculty members. The patient-nurse ratio is 2-3:1.

Universe and Sample: The population of the study consisted of patients hospitalized in the ICU between 2018 and 2019. The sample consisted of all patients hospitalized in the ICU between 1 January and 30 June 2018, and from 1 October 2018 to 31 March 2019.

The sample of the study was as follows: for VAP, all patients connected to mechanical ventilation; for catheter-related bloodstream infection, patients transferred to the ICU with a central catheter and a negative blood culture or a central catheter inserted by the intensive care doctor; for CA-UTI, all patients who were transferred to the ICU with a urinary catheter and had a negative urine culture or had a urinary catheter inserted in the ICU.

In addition, all patients with or without a catheter who were infected in the ICU were included in the study because of the possibility of developing a secondary infection. The study was completed with a total of 54 patients, 27 before the training and 27 after the training.

Data Collection: An Intensive Care Patient Data Form, a Socio-demographic Characteristics Form for Nurses, a Cost Analysis Table, the Pre-post Test Questionnaire for Nurses, and the Healthcare-Related Infections Prevention Care Bundle and Infection Prevention Care Bundle Control Form, developed by the researchers in consultation with the literature, wereused to collect the data.

The Intensive Care Patient Data Form featured 12 questions regarding the introductory characteristics of the patients, including age, gender, chronic diseases, glasgow coma scale, Apache II Score, the reason for hospitalization, intubation, presence of catheterization, antibiotic and steroid use, diet, and how patients left the ICU.

The Socio-demographic Characteristics Form for Nurses had six questions about the age, gender, education level, total time employed, time employed in the ICU, and previous training on HCAIs.

The Pre-postTest Questionnaire for Nurses was developed by the researcher after reviewing the literature in order to measure the knowledge of nurses working in the ICU about what points to consider in terms of preventing the development of infection (13,16-22).

The Cost Analysis Table consisted of data obtained from patient invoices to determine the medical costs of the patient in line with Social Security Institution (SSI) indicators. While these data were requested from the accrual department of the institution, the amounts invoiced to the SSI for each patient were requested through the Cost Table Form. The cost data to be used in the calculation of the medical costs in the form of the cost table were collected in nine groups: service (injection, vascular access, blood collection), medicine, laboratory, examination, pathology, consumables, medical imaging, bed and complication expenses.

The Healthcare-associated Infections Prevention Care Bundle was prepared based on the prevention guidelines and the parameters in the guidelines issued by the Association for Hospital Infections and Control in Turkey infection (13,16-22)

The Infection Prevention Care Bundle Control Form was prepared to indicate the patient's first name and surname, file number, age, gender, diagnosis, and at what time each day of the month compliance was observed for each of the parameters in the Infection Prevention Care Bundle. The Infection Prevention Care Bundle Control Form was filled out by the first researcher and the nurse in charge of the ICU.

Study Procedure: The research was completed in four stages between 1 January - 30 June 2018, and between 01 October 2018 - 31 March 2019 (363 days).

Stage One: After obtaining the permission of the ethics committee and the institution, how the research would work was discussed with the responsible physician and nurse of the chest diseases ICU, and it was requested that the whole team (physician, other assistant personnel, etc.) be aware of this.

Stage Two: The second stage of the study covered the training of the ICU nurses with regard to HCAIs. The content was prepared by the researcher after examining the relevant literature (16-24).

The training was given to the nurses by the first researcher. The nurses were split into two separate groups and each session lasted approximately three hours, with interactive discussions accompanied by visual materials. Before starting the training, nurses were informed about the research, and their written consent was obtained. A pre-test was applied before the training and the same questions were asked again after the training was over. At the end of the training, information was given about how to use the Healthcare-Associated Infections Prevention Care Bundle. The nurses were told that they would apply this bundle four times a day (at 10:00, 16:00, 22:00, and 04:00 hrs) to the patients who met the inclusion criteria. The nurses were asked to go to the patients who met the criteria at the desired hours and check the parameters in the care bundle.

Stage Three: The third phase of the study started with the implementation of the care bundle after the training. The Intensive Care Patient Data Form and the Infection Prevention Care Bundle Control Form were filled in by the first researcher and the nurse in charge for all patients hospitalized in the ICU.

Stage Four: In the last stage of the study, the quarterly infection rates between 1 October 2018 and 31 March 2019 were examinedand overall compliance with the bundle was evaluated. Pre-training Cost Analysis Table outputs and post-training Cost Analysis Table outputs were compared.

Ethical Considerations: Approval was obtained from the Clinical Research Ethics Committee of a Training and Research Hospital in Turkey (Date: 2017, Number: 36) for the ethical viability of the study. Following this, permission was obtained from the institution where the study was conducted. Written consent was also obtained from the nurses.

Statistical Analysis: The data obtained in the research were analyzed using the IBM SPSS Statistics 22.0 package program. Descriptive statistics (number, percentage, mean, standard deviation, minimum, maximum), the Wilcoxon test, the Pearson chi-square test, t-test for dependent groups, t-test for independent groups, and the Kruskal-Wallis test were used in the analysis of the data. The statistical significance level was accepted as $p<0.05$.

RESULTS

It is seen that the mean age of the 14 nurses participating in the study was 29.21±4.82. 78.6% were female, 92.9% had a bachelor's degree, and they had been working in the ICU for an average of 5 years, and 78.6% of them have previously received training in HCAIs (Table 1).

Table 1. Demographical data of the nurses

Variable	Group	N	%
Age		29.21±4.82*	
Gender	Female	11	78.6
	Male	3	21.4
Nursing program completed last	Bachelor’s degree	13	92.9
	Health vocational high school	1	7.1
Years of work in nursing		6.0±5.0*	
Years of work in intensive care		5.3±5.4*	
Healthcare-associated infections Training	Yes	11	78.6
	No	3	21.4

n: Number, %: per cent, *Average ± Standard Deviation

The nurses' mean scoresfor the nurses' pre- and post-education general HCAI test were 22.57±3.54 and 37.29±2.16 out of 40 points, respectively. It was observed that there was a significant increase in the scores of the nurses after the training (Z= -3.306, p=0.001). (Table 2).

Table 2. Pre-test post-test knowledge score distribution of nurses

	Pre-test		Post-test		Test Statistics
	x̄±SS	**Min-Max**	**x̄±SS**	**Min-Max**	
Healthcare-associated infections General Score	22.57±3.54	18-28	37.29±2.16	34-40	Z= -3.306, p=0.001*
Ventilator Associated Pneumonia Score	12.00±1.75	10-16	18.43±1.78	14-20	Z= -3.318, p=0.001*
Catheter Associated Bloodstream Infections Score	15.86±1.99	12-18	19.43±1.22	16-20	Z= -3.345, p=0.001*
Catheter Associated Urinary Tract Infections Score	12.29±1.89	10-16	18.71±1.49	16-20	Z= -3.330,p=0.001*
Total Score	62.71±6.00	52-72	93.86±4.25	86-100	t= -16.139, p<0.001**

Min: Minimum, Max: Maxium, *Wilcoxon Test, **T-test in dependent groups

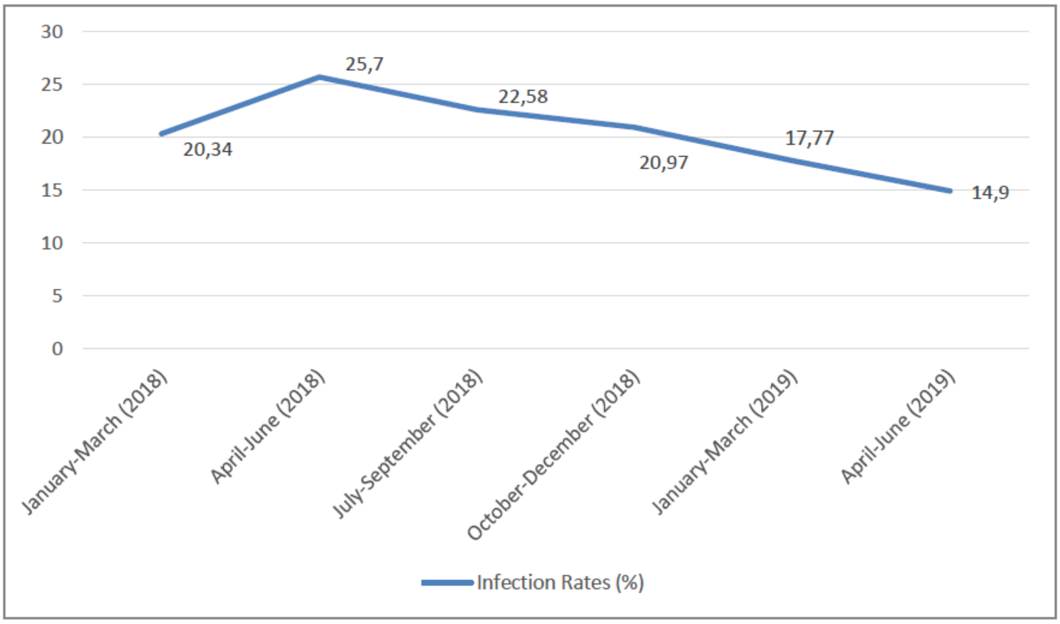
Although not given as a table, when we look at the compliance of the nurses to the Infection Prevention Care Bundle, it can be seen that compliance between 1 October and 31 December was 65%, while compliance between 1 January and 31 March was 63%.

Infection rates (in 1000 ventilation days) were 20.34 in the period January to March 2018, 25.7 in the period April to June 2018, 20.97 in the period October to December 2018, and 17.77 in the period January to March 2019. The infection rates of the four different periods were compared. As a result of the analysis, it was determined that the infection rates decreased compared to the pre-education period as seen in Chart 1 and it was determined that this decrease was not statistically significant (p>0.05) (Table 3; Graph 1).

Table 3. Comparison of the infection rates by periods

	January-March (2018)	April-June (2018)	October-December (2018)	January-March (2019)	Test Statistics
Number	12	14	13	11	χ2: 0.916*
Rate	20.34	25.7	20.97	17.77	p= 0.821

*Pearson chi square test



Graph 1. Infection rates by periods.

Although not given as a table, when the demographic data and disease characteristics of the patients before and after the education were examined, it was determined that all of them were similar and there was no statistical difference (p>0.05) between them.

The data on the costs obtained before and after the training in the study are presented in detail in Table 4. Accordingly, the average cost before the training was 11361.35₺ and the average cost after the training was 9149.87₺. The average cost of post-training decreased compared to pre-training. However, although this difference between the periods was not statistically significant (p>0.05), at the 95% confidence interval (6399.38₺-16323.32₺ and 4501.79₺-13797.95₺, respectively), the average cost was approximately 19% compared to the pre-training period. It is understood that this cost reduction was mainly because of the decrease in the infection rates and the decrease in the number of hospitalization days. In this context, average bed costs, which are the most important of all costs, decreased by 25.7% compared to pre-training at the 95% confidence interval (5241.86₺-13251.50₺ and 3489.03₺-10257.41₺, respectively). It was determined that there was no statistical difference in other sub-cost items (p>0.05) (Table 4).

Table4. Comparison of cost data by periods (₺)

Sort	Period	n	Min.	Max.	x̄	SS	SH	95% Confidence Interval		Test Statistics
								Lowest value	Upper value	
Beds	Pre-Training	27	584.00	38113.92	9246.68	10617.22	4004.82	**5241.86**	**13251.50**	p= 0.379* t= 0.887
	Post-Training	27	260.00	36524.85	6873.22	8971.84	3384.19	**3489.03**	**10257.41**	
Medicine	Pre-Training	27	0.00	10767.80	1466.77	2831.62	1068.08	398.69	2534.85	p= 0.770* t= -0.293
	Post Training	27	0.00	512.84	1741.39	3956.80	1492.50	248.89	3233.89	
Analysis	Pre-Training	27	0.00	527.88	223.07	119.96	45.23	177.84	268.30	p= 0.862* t= 0.174
	Post-Training	27	0.00	512.84	217.25	125.22	47.21	170.04	264.46	
Examination-Radiology	Pre-Training	27	0.00	33.68	10.64	9.21	3.46	7.18	14.10	p= 0.449* t= -0.768
	Post-Training	27	0.00	183.02	16.90	41.32	15.58	1.32	32.48	
Materials	Pre-Training	27	0.00	1192.79	212.28	241.16	90.96	121.32	303.24	p= 0.261* t= 1.137*
	Post Training	27	0.00	1100.62	141.16	217.89	82.18	58.98	223.34	
Consultation	Pre-Training	27	0.00	6.00	0.66	1.92	0.70	-.04	1.36	p= 0.180* t= -1.374
	Post-Training	27	0.00	36.00	2.66	7.31	2.74	-.08	5.40	
Blood Products	Pre-Training	27	0.00	584.90	68.77	151.01	56.95	11.82	125.72	p= 0.698* t= -0.390
	Post-Training	27	0.00	987.00	91.17	257.23	97.02	-5.85	188.19	
Intervention	Pre-Training	27	0.00	326.30	18.76	70.34	147.13	-128.37	165.89	p= 0.846* t= -0.195
	Post-Training	27	0.00	594.00	23.80	114.19	59.44	-35.64	83.24	
Other**	Pre-Training	27	0.00	1807.60	113.68	390.11	26.51	87.17	140.19	p= 0.382* t= 0.882
	Post-Training	27	0.00	799.20	42.27	157.64	43.06	-.79	85.33	
Total	Pre-Training	27	1008.05	45595.92	11361.35	13154.72	4961.97	6399.38	16323.32	p= 0.527* t= 0.638
	Post-Training	27	605.18	56145.37	9149.87	12322.56	4648.08	4501.79	13797.95	

n: Number, x̄: Average, Min: Minimum, Max: Maximum, SS: Standard Deviation, SH: Standart Error, *t-test in independent groups **İnvasive interventions

DISCUSSION

HCAIs are an important factor that increases costs due to the need for additional examinations and treatment interventions and prolongation of hospital stay (25). The economic dimension of HCAIs is a separate burden for the ICU due to both patient characteristics and treatment interventions (26). In the current study, it was concluded that the rate of infection, the length of hospital stay, and the associated cost decreased after the nurses' use of a care bundle developed for the prevention of common infections in the ICU. However, these decreases were not statistically significant. It is thought that the decrease in cost was due to the decrease in examination and treatment interventions due to the decrease in infection rates and the shortening of hospitalization.

When studies on the effect of the care bundle in the prevention of HCAIs are examined, parameters such as infection rate, length of hospital stay, and cost are discussed (3,27-30). In most of the studies, the evaluation criterion is infection rates, and studies examining the effect on cost are quite limited (31-33). In a study examining the effect of care bundle to prevent urinary catheter-related infections, it was concluded that a 71% reduction in infection rates was found with care bundle, and a cost savings of 30 816 $-120 696 $ per year (34).

In addition, Ferreira et al. (2016) found that the care bundle to prevent VAP provided a statistically significant reduction in hospital costs (35). Despite these studies in the literature, there are no cost-effectiveness studies in which the most common infections, CA-BSI, CA-UTI, and VAP are considered together in care bundle studies. Therefore, the results of this study will contribute to the literature in terms of both the use of care bundles for the three most common infections, and the cost analysis.

Studies on the prevention of HCAIs show that it is possible to achieve the goal of zero infections with the implementation of a care bundle of interventions with proven effectiveness to prevent a specific infection (3,11-13). In the current study, while the infection rates were 20.34/1000 ventilation days in the period January to March 2018, they were found to be 17.77/1000 in the period January to March 2019. It is seen that the infection rates indicate a decreasing curve compared to the previous year (Table 3; Chart 1). In addition, it was determined that the infection rates decreased when evaluated compared to the pre-education period, and this decrease was not statistically significant ($p>0.05$) (Graph 1).

HCAIs increase the length of hospital stay. In the study conducted by Jia et al. (2019), it was concluded that HCAIs cause an average increase of 10.4 days of hospitalization (36). In addition, the length of hospital stay is an important criterion used to evaluate the financial burden of HCAIs (37). In the study conducted by Leal and Freitas-Vilela (2021), it was concluded that the hospitalization cost of intensive care patients who developed HCAIs was four times higher than the patients who did not develop infections, and that there was a relationship between infection and longer hospital stay (38). In the study of Osme et al. (2021) with intensive care patients, it was stated that HCAIs prolong the length of stay in the hospital and place an extra burden on the health system (25). In the literature, examination of the economic dimension of HCAIs in the ICU is very limited, and existing studies have reached similar results to the present study (25,38). It is thought that the decrease in examination and treatment interventions in the present study, which was due to the decrease in infection rates and the shortening of the hospital stay, also caused a decrease in costs.

In the present study, as in the results of other studies, a significant increase was found in the knowledge scores of nurses about HCAIs (39,40). Although this was expected, the low level of compliance of nurses with the infection prevention bundle was not the desired result. In the literature, it is stated that the infection rate decreases when nurses' compliance with the infection prevention bundle increases (6,9,41,42). In the study conducted by Hassan and Wahsheh (2016) to determine the knowledge levels of intensive care nurses about VAP and its precautions, it was concluded that the knowledge levels of nurses increased significantly after the training (43). In a systematic review examining the effectiveness of education programs in VAP prevention, it was concluded that education provided a significant improvement in knowledge level and adherence to guidelines and a significant reduction in the incidence of VAP (44).

Although the knowledge of nurses increased in our study and the infection rates decreased following the application of the prevention bundle, the statistical insignificance of this decrease may be due to a decrease in compliance with the care bundle. From this point of view, it can be said that it is not enough to provide education on infection control alone, and strategies should be developed to increase compliance and behavioral change. Education can increase knowledge but may not lead to adaptations and changes to behavior.

There are limitations to the study, specifically that he sample was small. The limitation of the sample size could have been improved by prolonging the length of the study. In addition, a multicenter study could have yielded additional data.

CONCLUSION

In conclusion, this study determined that training provided a significant increase in the HCAI knowledge scores of the intensive care nurses, and there were decreases in HCAI rates, length of hospital stay, and cost after the training, although these were not statistically. The results of this study are similar to the literature in terms of showing the importance of infection prevention care bundles and it is thought that the study will aid future research by enabling the economic burden of HCAIs to be discussed using statistics. In addition, based on these results, it is recommended to conduct in-service training on care bundle in intensive care units and to repeat these trainings regularly.

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