



Original article

Efficacy of a care bundle to prevent multiple infections in the intensive care unit: A quasi-experimental pretest-posttest design study

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1. Introduction

Healthcare-associated infections (HAIs) are the most common complications in hospitalized patients worldwide (Çetinkaya-Şardan, 2010). HAIs, which threaten patient safety, cause extended hospitalization time and increase morbidity, mortality and treatment cost, are considered as the most important indicators of care quality in hospitals (Çetinkaya-Şardan, 2011; Ding et al., 2009; Oliveira, Kovner, & Silva, 2010). It is estimated that an HAI is developed in 1.4 million people around the world everyday. HAIs occur in 5–10% of hospitalized patients in developed countries and over 25% in developing countries (Pittet et al., 2008). More than 75% of these infections include catheter-associated urinary tract infections (CA-UTIs), ventilator-associated pneumonia (VAP) or central line-associated bloodstream infections (CLABSI) (Ertürk, Çopur Çiçek, Köksal, Şentürk Köksal, & Özyurt, 2012; Pittet et al., 2008).

When the infections related to healthcare are reviewed, approximately 60–80% of hospital-acquired UTIs develop in association with the catheter (Gray, 2004). Although it is not possible in this study to provide the general CA-UTI rate in Turkey, it is reported that these infections are the most frequent hospital-acquired infections (Arda et al., 2012). In a multicenter study, it was reported that approximately 65% of UTIs were associated with the urinary catheter (Leblebicioglu & Esen, 2003). As the second most frequent cause of HAIs, VAP is a serious complication, which develop in 8–28% of patients receiving mechanical ventilation support, mortality rate of which can raise up to 27–76% (Safdar, Dezfulian, Collard, & Saint, 2005).

It is reported that approximately 85% of hospital-acquired primary blood circulation infections are associated with the catheter and CLABSI rate change according to type of caterer and service. Every year, 80,000 CLABSI develop in intensive care units (ICUs) in the USA and the cost of each of these infections varies between USD 6,000–40,000 (Çetinkaya-Şardan et al., 2013).

While the incidence of HAIs varies by the country, hospital and patient characteristics, the hospital average is 3–17%. This rate could raise up to 25–50% in ICUs (Pittet et al., 2008). The factors which increase the risk of HAIs in ICUs include a severe clinical course of

hospitalized patients, high number of elderly patients, the presence of patients with an operation history, immunosuppressive medications, a trauma, metabolic disorder or malignancy, and the frequency of invasive procedures used on these patients (Rosenthal et al., 2006). Considering that 53.6% of HAIs result in death, it is important to prevent these infections (Alberti et al., 2002; Yüceer & Demir, 2009).

In hospitals, HAI rates are monitored by integrating infection control programs and quality improvement programs (Yokoe & Classen, 2008). HAI prevention studies indicate that it is possible to reach a target zero of hospital infection by applying bundled interventions which have demonstrated effectiveness in prevention of a certain hospital infection (Berenholtz et al., 2004; Cheema et al., 2011; Jarvis, 2007; Zingg, Walder, & Didier, 2011). In a study that aimed for zero CLABSI, the CLABSI rate decreased from 11.3/1000 catheter days to 0/1000 catheter days after intervention. This difference was found statistically significant (Berenholtz et al., 2004). The care bundle of Helmick et al., decreased VAP from 2.50 to 1.60 per 1000 ventilator days and CLABSI from 2.38 to 0.73 per 1000 catheter days (Helmick et al., 2014). Similarly, it was reported VAP infection rates decreased from 4.08 to 1.16 per 1000 ventilator days (Eom et al., 2014).

According to evidence-based studies, integration of care bundles is critical in intensive care patients. Especially, when compatibility is maximized, care bundle effectiveness increases and leads to decreased mortality and morbidity (Helmick et al., 2014; Horner & Bellamy, 2012; Raad, 2012). Implementation of care bundles creates an important opportunity to deliver evidence-based, safe healthcare to patients with using a multidisciplinary approach. Obtaining the desired results requires evidence-based bundle components that should be simple to apply. Also, compatibility should be monitored and feedback should be provided to authorities (Çetinkaya-Şardan, 2010).

Intensive care nurses, who accompany the patients for 24 h, have important responsibilities in implementing and inspecting care bundles. It is reported that accompaniment of the nurse during implementation and control of these bundles increases compatibility by 100% (Berenholtz et al., 2004; Raad, 2012). Intensive care nurses administer the bundle interventions and maintain continuous patient care, hence, it is important that they are aware that HAIs are preventable and they

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Box 1

Sub-parameters of the HAI prevention care bundle.

VAP	CLABSI	CA-UTI
Bedhead height suitable. No need for aspiration. No need for oral care. Cuff pressure suitable. No liquid accumulation in the ventilator circuits. Ventilator circuits are not dirty. Peptic ulcer prophylaxis received. Deep vein thrombosis prophylaxis received.	The need for catheter continues. Central venous catheter's dressing need has been met. Dressing has been suitably applied. Dressing date available. Fluid sets have been replaced.	The need for catheter continues. The urinary bag and catheter are below the bladder level. No withdrawal from the urinary bag. The urinary bag does not touch the floor.

keep abreast of universal measures to prevent and control infections and deliver the most effective care to patients by reinforcing their knowledge with practice (Yüceer & Demir, 2009).

Considering relevant literature studies, infection prevention care bundles are only applied in a single area. However, intensive care patients are mostly attached to a ventilator and/or a urinary and/or central catheter. An intensive care nurse treats the patients with integrity and deliver care for all interventions within the scope of integral patient care. The difference of this study from similar studies in the literature is that interventions for all three of the most frequent ICU-acquired infections, VAP, CLABSIs, and CA-UTIs, are discussed in the care bundle. The infection rates decreased with increased compatibility of the care bundle. From this perspective, the present study is believed to contribute to the nursing literature.

2. Methods**2.1. Study design**

The study is a quasi-experimental pretest-posttest design aimed at evaluating the efficacy of a care bundle prepared to prevent three of the most frequent infections acquired in ICUs.

2.2. Study setting

This study was conducted in the adult Anesthesiology ICU in Turkey between 1st April – 30th September 2015.

2.3. Samples

All patients older than the age of 18 and receiving invasive mechanical ventilation therapy, or a central line catheter or urinary catheter at a University Hospital Anesthesiology ICU between 1st April and 30th September 2015 were included in the study, providing their family member consents are obtained. One hundred twenty patients were admitted to the ICU during the data collection. The sample comprised all patients attached to a mechanical ventilator for VAP, patients who were transferred to the ICU with a central catheter inserted and who had negative blood culture, or were attached to a central catheter by the intensive care physician for a CLABSI and all patients who were transferred to the ICU with a urinary catheter inserted and who had negative urinary culture or who were attached to a urinary catheter in the ICU for a CA-UTI.

2.4. Data collection

The tools developed by researchers (Alp et al., 2012; Arda et al., 2012; Arman et al., 2008; Çetinkaya-Şardan, 2010; Çetinkaya-Şardan

et al., 2013; O'Grady et al., 2011; Pittet et al., 2008; Rello et al., 2002; Rosenthal et al., 2006; Safdar et al., 2005; Usluer et al., 2006) were used. Five forms were included.

Form I provided identifying characteristics of the nurses, which are their age, gender, educational status, tenure as a nurse, tenure in intensive care and previous HAI training.

Form II comprised the pre- and post-test question form to evaluate the infection prevention knowledge level of the ICU nurses. The form contained two parts; part one included 20 multi-choice questions (five choices per question) and part two contained 30 true-false questions. The multiple choice questions covered all strategies for HAI prevention. The true-false questions comprised propositions considering VAP, CLABSIs, and CA-UTIs constituting the main aims of this study. Comprehension levels of the items in the question form were determined by the content validity index. Analyses found the form had a content validity index of 1. The form was distributed to all nurses simultaneously and allowed 20 – 25 min for completion.

Form III comprised the care bundle control form. This form demonstrated the days and hours to monitor compatibility with each of the parameters in the care bundle and the patient's name, surname, file number, age, gender, and diagnosis. The form was filled out by two nurses who attended the training but were commissioned outside the ICU. To prevent bias in the study, the ICU nurses were not informed about the hours of monitoring compatibility with the care bundle.

Form IV comprised the training material prepared for the ICU nurses. The training content was examined by six academic members and one infection committee nurse. Any necessary adjustments were made according to the feedback received.

Care bundle (**Form V**) was prepared based on evidence-based interventions in related literature (Berenholtz et al., 2004; Pittet et al., 2008; Rello et al., 2002; Rosenthal et al., 2006; Safdar et al., 2005; Usluer et al., 2006) and guidelines (the Centers for Disease Control and Prevention/ CDC, Turkish Society of Hospital Infections and Control/ HİDER, Arman et al., 2008; O'Grady et al., 2011; Alp et al.; Arda et al., 2012; Çetinkaya-Şardan et al., 2013). Care bundle consists of most common three chapter of HAIs, CA-UTIs, VAP and CLABSIs. As seen Box 1, each chapter contains sub-parameters. Additionally, the care bundle includes name, surname, file number, age, gender, and diagnosis of each patient. Content validity of infection prevention care bundle was analyzed by experts in the field, six faculty members and one infection committee nurse in order to evaluate subject relevance. Scoring forms were handed out to the experts along with the form. Content validity index of the care bundle form was found 1, higher than determined minimum score after analyses (Confidence coefficient: $1 - \alpha = 1 - 0.05 = 0.95$).

2.5. Intervention and measures

The study was conducted in three stages. In stage one, all physicians, nurses and other auxiliary staff in the ICU were informed of the study. Training was planned for the nurses who consented (verbal and written consent) to participate. A pre-test was applied before the training and the same questions were asked after training.

Once training was complete, the nurses were informed about how to use the care bundle and instructed to apply the bundle four times a day at 10:00, 16:00, 22:00, and 04:00 h, to the patients who met the study criteria. The nurses were asked to control the parameters in the bundle by visiting the patients at the pre-determined times. For example, in the VAP section, considering the “bedhead height suitable” statement among the sub-parameters, the patient should be checked and the form should be marked with (+) if it is suitable or (–) if not suitable and replaced with (+) after correcting the bedhead. The purpose of replacing the mark was to prevent the needed practice from forgotten.

The nurses in charge of controlling compatibility with the care bundle were instructed on how to fill out the bundle control form and asked to visit ICU on the days and hours determined by the researcher, to check whether it was filled. If the bundle was not filled, they would state “not filled”. If filled, they were asked to visit the patient and control every parameter. For example, if there was a (+) next to the statement “the need for catheter continues”, a sub-parameter in the CA-UTI section of the care bundle, it would be controlled by visiting the patient. Thus, a (+) for suitable and (–) for not suitable, would be marked a long with the time and day of the visit for every page reserved for every patient in the bundle control form.

The second stage started with the care bundle implementation. During orientation, the chief nurses and nurses in charge of controlling compatibility monitored the intensive care nurses and answered any of their questions. The compatibility with the package in the orientation process, was 52.9% for the VAP, 53.3% for the CLABSI and 88.7% for the CA-UTI section, and the study was implemented 18 days after orientation. In the first 3 months following the orientation process (April – June), infection rates were monitored and feedback was given to the nurses. Problematic titles in compatibility, such as “liquid in ventilator circuits” were discussed between the chief nurse and intensive care nurses during short visits, in the form of questions and answers.

In stage three, implementation continued after the feedback, infection rates were monitored for another 3 months (July – September) and nurses' compatibility with the bundle was evaluated. Infection rates were obtained from the hospital infection control committee and each period was compared to the previous 3-month period. The infection control committee members were not informed of the study.

2.6. Ethical considerations

Written permission was obtained from Hospital before starting the study. Ethical compliance was granted under protocol number B.10.4İSM.4.06.68.49, from the Clinical Research and Ethical Board. Verbal and written permissions were obtained from the nurses and verbal consent from relatives of the patients involved in the study.

2.7. Statistical analysis

IBM SPSS Statistics 21.0 (2012-IBM-SPSS Statistics for Windows, version 21.0 Armonk, NY:IBM Corp.) was used for statistical analyses and calculations. The study data was evaluated in three stages.

In the first stage, the Shapiro – Wilk test was used if the continuous variables (e.g. age, knowledge scores) of the nurses exhibited a normal distribution. Demographic characteristics used the mean $\pm$ standard deviation values (mean $\pm$ SD), median (min – max) and mean $\pm$ SD. The pre- and post-test scores were compared by Student's t-test for dependent groups.

In the second stage, the parameters under each heading (CLABSI, VAP and CA-UTI) of the care bundle control form filled out for every patient hospitalized in the ICU between 1st April 2015 – 30th September 2015 were evaluated. If all parameters had a (+), it was considered compatible, and if at least one parameter had a (–), it was considered incompatible. Additionally, all parameters with a (–) were determined.

In the third stage, Chi-square tests were used to evaluate the infection rates and compatibility of nurses with the package during April – June 2015 and July – September 2015. The lowest significant difference was calculated for pair-wise comparisons.

3. Results

3.1. Characteristics of the participants

The 30 nurses enrolled in the study were aged between 22 – 44 years with a mean age of 29.63 ± 5.25 years, 90.0% ($n = 27$) were female and 83.3% ($n = 25$) had previously attended HAI training. The average test scores before and after training were 50.3 ± 11.7 and 64.0 ± 12.4 , respectively, showing a significant increase after training ($t = -4.394$, $p < 0.001$). The pre- and post-test average scores were 53.3 ± 11.5 and 71.3 ± 12.8 for VAP, 59.7 ± 13.3 and 74.0 ± 15.9 for CLABSI and 54.0 ± 11.9 and 74.0 ± 17.5 , for CA-UTI, respectively. A significant increase in knowledge scores was obtained after training, VAP ($t = -5.721$, $p < 0.001$), CLABSI ($t = -3.794$, $p < 0.001$) and CA-UTI ($t = -5.166$, $p < 0.001$), respectively (Table 1).

3.2. Impact of the infection prevention care bundle and compatibility of nurses with the care bundle on infection rates

Table 2 shows the compatibility of nurses with the bundle. Their compatibility with the VAP section of the care bundle was 44.4% in April – June ($n = 564$) and 40.0% in July – September ($n = 490$). The difference between the two periods was statistically significant ($\chi^2 = 4.091$, $p = 0.043$). Similarly, the compatibility of nurses with the CLABSI and CA-UTI sections of the bundle decreased in July – September compared to April – June ($p < 0.001$).

The VAP infection rates, were 23.4, 12.6, and 11.5 per 1000 ventilation days in January – March, April – June and July – September (Table 3). The infection rates significantly decreased between January – March and April – June ($\chi^2 = 6.934$, $p = 0.031$) but no significant decrease occurred between April – June and July – September. Similarly, there was a decrease in infection rates between January – March and April – June for CLABSI (8.9 and 4.2 per 1000 catheter days, respectively) but it was not statistically significant ($p > 0.05$) (Table 3). Comparing April – June with January – March for CLABSI, it was seen the CA-UTI infection rates decreased (6.7 and 5.7 per 1000 catheter

Table 1
The scores of nurses about healthcare associated infections.

	Pretest mean $\pm$ SD ^a	Posttest mean $\pm$ SD	t ^b	p ^{***}
Knowledge test about HAI	50.3 $\pm$ 11.7	64.0 $\pm$ 12.4	– 4.394	< 0.001
Fri – VAP	53.3 $\pm$ 11.5	71.3 $\pm$ 12.8	– 5.721	< 0.001
Fri – CLABSI	59.7 $\pm$ 13.3	74.0 $\pm$ 15.9	– 3.794	< 0.001
Fri – CA-UTI	54.0 $\pm$ 11.9	74.0 $\pm$ 17.5	– 5.166	< 0.001

Note: HAI = Healthcare-associated infections; Fri = frequently reported infections; VAP = Ventilator-associated pneumonia; CLABSI = Central line-associated bloodstream infections; CA-UTI = Catheter-associated urinary tract infections.

^a SD, standard deviation.

^b t, test statistics.

*** $p < 0.05$, statistically significant.

Table 2

The nurses' compatibility with the infection prevention care bundle.

Care bundles	Months	Compliance status of nurses				Test results	
		Compatible		Not compatible		χ^2	p**
		n ^a	%	n	%		
VAP	April–June	564	44.4	705	55.6	4.091	0.043
	July–September	490	40.0	722	60.0		
CLABSI	April–June	555	47.0	627	53.0	59.395	< 0.001
	July–September	308	30.8	693	69.2		
CA-UTI	April–June	1211	87.1	179	12.9	607.632	< 0.001
	July–September	516	41.4	730	58.6		

^a n: initiative number.

** p < 0.05, statistically significant.

days) but it was not statistically significant ($p > 0.05$). During July – September, more CA-UTI infections were observed than the other two 3-month periods but it was not statistically significant ($p > 0.05$) (Table 3).

Considering the sub parameters under each section in the care bundle, the most frequent problem in the VAP parameters was the accumulation of liquid in ventilator circuits at 48.9% ($n = 345$) in April–June. In July–September, 50.6% ($n = 365$) of the bundles were never filled and 21.7% of the patients did not receive oral care ($n = 157$). Considering the CLABSI parameters, 51.7% of the dressing dates were not recorded ($n = 324$) in April–June, whilst 39.6% ($n = 274$) of the bundle was not filled in July–September, with the dressings not suitably applied to patients showing the highest incompatibility rates (26.4%; $n = 183$). Considering the CA-UTI care bundle parameters, 12.8% ($n = 23$) of the urinary bags contacted the floor in April–June, 50.1% of the bundle was not filled ($n = 365$) in July–September and withdrawal from the urinary bag occurred at the highest rates of 39.0% ($n = 285$).

4. Discussion

HAIs extend hospitalization time, increase treatment costs and cause high morbidity and mortality rates. HAIs particularly occur in the ICUs. The most important reasons of these are that invasive procedures are more frequent in the ICU than other departments and resistant micro-organisms are more common in this field (Orucu & Geyik, 2008; Ding et al., 2009; Oliveira et al., 2010; Çetinkaya Şardan, 2011).

Patient care in the ICU has gained increasing importance because possible complications are largely preventable. HAIs, particularly VAP, is considered a preventable medical error (Beattie, Shepherd, & Maher, 2012). Surgical site infections, VAP, CLABSIs, and CA-UTIs are the most common HAIs in the ICU. The CDC and US Public Health Service consider HAI as an indicator of patient care quality in the ICU (Jha, Orav, Ridgway, Zheng, & Epstein, 2008; Tablan, Anderson, Besser, Bridges, & Hajjeh, 2004). Studies on HAI prevention demonstrated that proven practices effectively decrease infection rates when applied as a

bundle (Berenholtz et al., 2004; Cheema et al., 2011; Zingg et al., 2011). Particularly, when compatibility with the bundle to prevent infection is maximized, the efficacy of the bundles increases, which leads to a decrease in mortality and morbidity (Horner & Bellamy, 2012).

Implementation of care bundles creates an important opportunity to deliver evidence-based and safe healthcare to patients with using a multidisciplinary approach. One of the important obstacles concerning compatibility with evidence-based guidelines is the lack of information. Although a lack of information is not the sole reason for incompatibility, theoretical information is inevitably necessary to develop efficient prevention approaches. Training programs that are organized according to the principles of preventing infections lead to a decrease in the HAI rate, which indirectly confirms the importance of theoretical information (Labeau, Vandijck, Claes, Van, & Blot, 2007). The manual developed by the CDC for HAI prevention emphasizes that staff training is one of the most important criteria (Tablan et al., 2004). Previous studies have demonstrated the positive effects of staff training in HAI prevention (Rosenthal et al., 2006; Zack et al., 2002). For example, in guidelines developed for VAP prevention, training programs, feedback and control for nurses decreased significantly VAP development (Burns et al., 2003; Zack et al., 2002). In our study, although 83.3% of the nurses had previously received HAI training, the knowledge scores increased significantly after training.

Although training improved the knowledge of health personnel, it was not exclusively effective in infection prevention. It is particularly important to control compatibility of the personnel with the bundle. When compatibility with the bundle is not controlled, a decrease in compatibility levels is inevitable after training. A study conducted at various centers of Europe reported a low 53% compatibility rate with VAP prevention rules. Deficient materials (31%) and cost increase concerns (16.9%) in the ICU were considered as the main reasons for incompatibility (Rello et al., 2002). In our study, compatibility with the VAP was 44.4% in April – June and 40.0% in July – September. The most important reason of incompatibility in our study was suggested to be the changing nurse-to-patient ratio.

Table 3

Infection rates before and after the care bundle.

Months	January–March		April–June		July–September		Test results	
Care bundles	n (Rate ^a)	%	n (Rate)	%	n (Rate)	%	χ^2	p
VAP	30	23.4	16	12.6	14	11.5	6.934	0.031
CLABSI	10	8.9	5	4.2	10	9.9	2.813	0.245
CA-UTI	10	6.7	8	5.7	13	10.4	2.107	0.349

^a (Number of infections developed in the monitoring period/Invasive tool day) × 1000.

In our study, despite the low compatibility rate, when VAP rate in April – June was compared to the previous 3-months, the infection rate decreased significantly from 23.4 per 1000 ventilator days before intervention to 12.6 per 1000 ventilator days in April – June ($p < 0.05$). No further decrease in VAP rate (11.5) was obtained in July – September, while compatibility rate decreased further. In the interventional study, when checklists were used to monitor compatibility with a VAP, VAP rate decreased from 4.2 to 0.7 per 1000 ventilator days, yet, when the daily checklists were not completed, this rate increased to 4.8/1000 ventilator days (Cheema et al., 2011). Hawe, Ellis, Cairns, and Longmate (2009) investigated compatibility with a VAP bundle between active and passive participation. During the active period, VAP infection rates decreased from 19.2 to 7.5 per 1000 ventilator days, however, during the passive period, compatibility was very weak and infection rates increased (Hawe et al., 2009). In another study that also used a VAP bundle, the infection rate decreased from 15.9/1000 ventilator days before intervention to 8.5/1000 ventilator days after intervention (Alcan, Korkmaz, & Uyar, 2016).

In this study, the infection prevention care bundle included some evidence-based parameters under each of the three studied ICU-acquired infections. When the nurses demonstrated incompatibility even with a single parameter, they were considered to have not applied the bundle. Thus, the parameters with which nurses demonstrated incompatibility, could be identified to assist planning of future training and interventions. The highest incompatibilities in the VAP section were, “problem of accumulation of liquid in ventilator circuits” and “lack of oral care of patients”. In the CLABSI section, “failure in recording dressing dates” and “properly administering dressing”, showed the highest incompatibilities, while “the urinary bag contacting the floor” and “withdrawal from the urinary bag”, were the highest in the CA-UTI section. It is important to educate nurses in order to raise their awareness of the identified parameters. Problematic titles in compatibility, such as “liquid in ventilator circuits” were discussed between the chief nurse and intensive care nurses during short visits, in the form of questions and answers.

Among HAIs in the ICU, CLABSIs are a preventable morbidity and mortality risk, which causes high costs (Halton, Cook, Paterson, Safdar, & Graves, 2010). A study demonstrated that using a CLABSI bundle zeroed infection rates (Tatafi et al., 2015). Considering the CLABSI rate in our study, when compared with January – March, the infection rate decreased from 8.9 to 4.2 per 1000 catheter days in April – June but this was not statistically significant ($p > 0.05$). Along with further decrease in compatibility in July – September, the CLABSI rate increased (9.9/1000 catheter days), this was not statistically significant either ($p > 0.05$). Provonost et al. (2006) applied a bundle over 6 – 12-months to decrease CLABSI rates in 103 ICUs and decreased the infection rate from 7.7 to 1.4 per 1000 catheter days (Provonost et al., 2006). Similarly, other study showed that a CLABSI bundle decreased the infection rate from 9.0/1000 catheter days before intervention to 2.7/1000 catheter days after intervention (Kim, Holtom, & Vigan, 2011). In another study, a CLABSI bundle was able to decrease infection rate from 7.7/1000 catheter days before intervention to 1.1/1000 catheter days after intervention (Waters et al., 2011). Furuya et al. (2011) demonstrated a very strong association between CLABSI rates and bundle compatibility in their study of 312 ICUs (Furuya et al., 2011). The results of our study suggest decreased compatibility with the CLABSI bundle cause an increase in the associated infection rate.

Urinary catheters are used by 75 – 90% of intensive care patients and this extends hospitalization time and causes mortality. It is reported that after frequent use, particularly in ICUs, urinary infections are among the most common HAIs with 30 – 40% and the source of 80% of these urinary infections is urinary catheterization (Akpınar, Yurttaş, & Karahisar, 2004; Wilson et al., 2009). In our study, CA-UTI rate decreased from 6.7 to 5.7 per 1000 catheter days, however, it was not statistically significant ($p > 0.05$). Additionally, along with a

further decrease in compatibility in July – September, CA-UTI rate increased (10.4/1000 catheter days). In another study, which applied a similar bundle, CA-UTI rate decreased from 107.4 to 29.5 per 1000 catheter days (Amine, Helal, & Bakr, 2014). In a study applied a bundle to prevent CA-UTIs, it was seen the infection rate decreased from 5.2 to 1.5 per 1000 catheter days (Clarke et al., 2013). In our study, it is suggested that in particular, the significant decrease in compatibility with the CA-UTI bundle affected the infection rate.

In this study, infection rates decreased with increased bundle compatibility. While some literature studies report no association between bundle compatibility and infection rates (Jeffries et al., 2009), others show a positive association (Rello et al., 2013; Wigmore & Sethuraman, 2014). A study reported a decrease in VAP and CLABSI infection rates after their bundle intervention, however, found no correlation between compatibility rates or control rates and infection rates (Helmick et al., 2014). In contrast, it was reported that when ICUs used bundles with 95% or higher compatibility, infection rates decreased (Raad, 2012). In this context, it is important to identify the factors which affect bundle compatibility. Considering the reasons for incompatibility in our study, we found that the number of nurses decreased throughout the study duration. In particular, the nurse-to-patient ratio (start, 3:1; second period, 5:1) decreased in the second 3-month period of the study. In this instance, the number of patients per nurse in the intensive care increased, and thus the workload increased. A sufficient ICU nurse availability is important for decreasing and preventing HAIs (Sungur, 2011). A decrease in the number of nurses per patient is reported to be associated with CLABSI risk (Çetinkaya-Şardan et al., 2013). Moreover, according to the feedback we received during the study, a critical lack of material was reported. In developing countries, a lack of materials and nurses was most commonly associated with HAIs (Amine et al., 2014; Rosenthal et al., 2010).

Inspection is known to be important to improve compatibility with bundles. In our study, particularly in the second period, when compatibility with the bundle decreased, the long-term absence of a nurse in the intensive care, namely, the absence of authority, was suggested to have an important impact on the results. Some studies reported high HAI rates resulted from a lack of quality control measures and inspections (Higuera et al., 2005; Karabey, Ay, Derbentli, Nakipoglu, & Esen, 2002; Rosenthal, McCormick, Guzman, Villamayor, & Orellano, 2003).

Our study aimed to decrease infection rates by using an infection prevention bundle. Despite the decrease in infection rates, particularly in the VAP and CLABSI rates, these results were lower than expected. However, the ability to implement three care bundles at the same time and assess the compatibility of the nurses with these bundles are highlights of this study. Furthermore, the findings are important motivation factors for further research.

4.1. Clinical implications

ICUs commonly use invasive procedures. Thus, HAIs are frequent in intensive care. HAIs cause an increase in mortality, morbidity and treatment cost. Various interventions are available to prevent HAIs. This study found that infection rates decreased when compatibility with the care bundles was ensured. The care bundle used in this study was a simple, cost-effective, time-efficient and reliable approach to decrease ICU-acquired HAIs. Therefore, care bundles can be readily added to hospital protocols to prevent HAIs and should be used in all ICUs.

4.2. Limitations

The most important limitation of this study was the increase in the patient-to-nurse ratio. The patient-to-nurse ratio was 3:1 at the beginning of the study but increased to 5:1 in the second stage.

5. Conclusion

In conclusion, it is necessary to use infection control programs efficiently and ensure control to prevent or at least decrease HAI frequency. However, ensuring compatibility of the nurses is insufficient to decrease infection rate on its own. It is necessary to offer training and ensure bundle implementation and participation of all healthcare personnel commissioned in the ICU. These practices are required in ICUs where the factors that affect compatibility with care bundles are examined.

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