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THE IMPACT OF INTRODUCING A NURSING EDUCATION PROTOCOL ON THE INCIDENCE OF CLOSTRIDIUM DIFFICILE INFECTIONS IN THE HOSPITAL ENVIRONMENT: A QUASI-EXPERIMENTAL STUDY

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Introduction: Increased virulence of *Clostridium difficile* and use of antimicrobial drugs in recent years represent a challenge in the treatment of these infections in healthcare institutions. Improving the overall knowledge on prevention and control of *C. difficile* infections (CDI) among nurses may be one strategies to help reduce the CDI incidence rate in hospital settings.

Objective: The research objective was to develop, implement and evaluate a protocol for the prevention of CDI in hospital environment through nurses' education.

Materials and Methods: This study utilized a quasi-experimental pretest–post-test design, which was carried out in tertiary care hospital, Banja Luka, Bosnia and Herzegovina. The educational modules contained detailed description of prevention measures to prevent CDI transmission, and *C. difficile* toxins in faces were identified using laboratory enzyme immunoassays.

Results: The research included 60 nurses. There was a statistically significant difference ($p=0.001$) in the evaluation of knowledge in relation to professional experience and education level before the intervention. Nurses showed highly significant ($p<0.001$) better knowledge about *C. difficile* and CDI prevention on the test after the education. Before the education of nurses and technicians on preventive measures, CDI incidence was 11.04 per 10,000 patient - days, and after the education 6.49.

Conclusion: The study results showed that continuous medical education about CDI can have contribute to increasing knowledge and awareness about the importance of CDI prevention.

Keywords: *Clostridium difficile*, infection, prevention, nurses, education.

INTRODUCTION

Hospital-associated diarrhoeas are most often the result of an infection caused by *Clostridium difficile* (CDI), and the prevention of these infections has public health significance. Decreasing the CDI rate is challenging due to the complex pathogenesis, a many number of colonized patients and the presence of infectious spores [1,2]. The spreading of CDI is a consequence of the uncontrolled use of antibiotics and inappropriate control of hospital-acquired infections (HAI) [3-5]. Therefore, the prevention and control of CDI in healthcare institutions nowadays requires two basic approaches: preventing horizontal spreading of *C. difficile* and decreasing the risk of CDI in case the infection spreads. The first approach to CDI control involves isolating the infected patient and cleaning and disinfecting the hospital environment according to the guidelines [6,7]. Another approach is to control the use of antibiotics [8,9]. Strategies and guidelines for the prevention of CDI are based on a bundle of measures or a set of data that lead to the best possible outcome. The CDI prevention bundle consists of individual elements or interventions, as it follows: diagnostic testing, empirical control, contact isolation, hand hygiene and disinfection of the hospital environment. Successful implementation of the CDI prevention bundle depends on several persons: physicians, nurses, caregivers, personnel in charge of hygiene, family members and others who are in contact with patients [10]. Considering the high incidence of CDI, healthcare professionals should be familiar with the latest guidelines in the treatment and prevention of CDI [11,12]. Faecal microbiota transplantation (FMT), also called faecal transplantation or faecal bacteriotherapy, is one of the more important, newer approaches to the treatment of CDI. FMT is the infusion of a suspension of faces from a healthy donor into the colon of the CDI patient [13,14]. Nurses have an important role in the modern approach to the treatment of CDI patients, such as FMT and primarily if those patients are housed in an intensive care unit (ICU). Enteric preventive measures and proper isolation of patients with CDI are crucial care procedures [15,16]. Nurses should be alert that after FMT, antibiotic exposure can still lead to recurrent CDI [17]. There is

evidence that educational interventions improve the knowledge and practice of nurses with regard to infection prevention both in hospitals and nursing homes [18,19]. Educational interventions included evidence-based information on the etiology, epidemiology, diagnosis, treatment, transmission and prevention of CDI, such as hand hygiene, isolation measures and the use of antibiotics [20-22]. Staff education is one of the most successful measures to prevent the spread of *C. difficile*, which should include not only medical staff (nurses and physicians), but also non-medical staff, especially those responsible for maintaining the hygiene of the hospital environment [23]. Spagnolo et al. (2018) presented in their research how a multidisciplinary approach to the prevention of CDI, which included several interventions, one of which was the education of nurses and hygiene personnel, proved to be successful in controlling the epidemic in one Italian hospital [24]. However, recent studies published that health workers are not properly following the CDI prevention measures. Some of the possible reasons include more and more complex preventive procedures that lead to confusion and gaps [25–27].

Data from the literature indicate that certain individual and socio-demographic factors, including knowledge, length of service or work experience, gender and type of profession influence adherence to infection prevention and control procedures [28]. However, even when hospital infection prevention protocols are followed, outbreaks of any infectious disease, including CDI, may occasionally occur. Therefore, it is important for nurses to update their knowledge on how to prevent HAI, and about the control and management of infections in healthcare facilities [29]. Continuous educational programmes, professional training and ensuring the availability of the necessary guidelines represent essential steps for improving the knowledge and practice of nurses in relation to the prevention of HAI [30]. Different educational strategies are being used to improve nurses' knowledge and practice of infection control. Some of the most often used methods include quasi-experimental research in which control and target groups are subjected to both didactic and practical sessions, training based on pre-prepared scenarios, e-learning with a questionnaire and

focus group discussions, and computer-assisted learning in infection control education [31]. Due to the rapid pace of scientific discoveries, technological innovations and social changes, knowledge quickly becomes outdated. Andragogy is a useful model for planning and facilitating adult learning [32]. Problem-based learning (PBL) is also an effective educational strategy that can improve critical thinking skills in infection prevention and control [33,34].

Nurses make the largest group of health workers in the healthcare system. They provide services in hospitals seven days a week throughout the year and are in close contact with patients and their families. Nurses working in different hospital departments play an important role in HAI prevention [35]. The present relevant literature has only a few published studies that evaluate the knowledge, perception and practice of nurses regarding CDI [36]. A recently conducted study from Bosnia and Herzegovina showed that nurses' knowledge about CDI prevention is not at a satisfactory level, which indicates an increasing need for educating nurses about this issue [37].

Therefore, the present study was planned bearing in mind the importance of nurses in CDI prevention, and the importance of an educational intervention on the behaviour of nurses in the practice of infection control.

Objective: The research objective was to develop, implement and evaluate an educational module for the prevention of CDI in the hospital environment through the education of nurses in order to improve the level of knowledge and practice among them.

MATERIALS AND METHODS

Design

The research design used in this study was quasi-experimental design with one group design pretest-posttest approach.

Research Time and Place

The study was conducted in the University Clinical Centre of the Republic of Srpska (UKC RS) in Bosnia and Herzegovina, from April to June 2020.

Study Population

The target population consisted of nurses working in ICU, Clinic for Internal Diseases, Clinic for General and Abdominal Surgery, Clinic for Infectious Diseases and Clinic for Oncology.

Based on a G*Power 3.1.9.4 program calculation of medium effect size, power set at 0.80, and a set at 0.05, a minimum of 47 participants is required. Considering a typical dropout rate of 10% for the experimental design used, 57 is the minimum required sample. The scope in the study initially included 75 participants, but excluded 15 with incomplete answers. A final sample of 60 was reached of nurses who have fully completed the education program, pretesting, and post-testing. Participants were selected from the total population using a simple random technique.

Inclusion and Exclusion Criteria for Nurses population

According to the defined criteria for inclusion in the study, the subjects were nurses providing direct care to patients, of all educational profiles, employed at these clinics, aged 18-65, having passed the state exam (nurses licensed to practice) and working 8 and 12 hours shifts. Nurses working on administrative assignments were not included in the study, according to the defined criteria. The criteria for exclusion at the study were the nurses with incomplete answers.

Inclusion and Exclusion Criteria for Patients population

The study included patients with CDI who were older than 18 years of age and hospitalised at the Intensive Care Unit (ICU), Clinic for Internal Diseases, Clinic for General and Abdominal Surgery, Clinic for Infectious Diseases and Clinic for Oncology, from July to December 2019 (before the

intervention) and from July to December 2020 (after the intervention). These clinics were selected for the purpose of the study because they treated patients with increased risk for CDI and had an increased incidence of *C. difficile* infections in 2019.

A case of hospital-acquired CDI (HA-CDI) was defined according to the criteria of the *C. difficile* Study Group of the European Society of Clinical Microbiology and Infectious Diseases as follows: any patient who developed symptoms of diarrhoea at least 48 hours after admission to the hospital (HA-CDI case with hospital onset); any patient who was admitted with symptoms of diarrhoea at the hospital with an onset of symptoms in the community within 4 weeks following discharge from the hospital (HA-CDI case with community onset) and patients who had stool samples positive for CD toxin A or B or positive for toxin-producing CD [25]. Only the first positive test for *C. difficile* in patients during the current hospitalization was included in the study. If patients had more than one positive test during the study period, we included only the first episode. Paediatric population of CDI patients, was not included in the study, along with community-acquired CDI.

Educational Intervention

The educational modules contained detailed description of prevention measures against the transmission of the *C. difficile* in hospital settings in accordance with the guidelines [6,7], and their implementation would affect the patient's safety during hospitalisation and the treatment outcome. Each educational module was based on adult learning theories for interactive, self-directed learning, which developed interactive teaching, increased the motivation and interest of nurses, and at the same time made it easier to follow and remember the issue [31-33]. For more successful learning, we used numerous teaching aids (blackboard, flip chart, computers and LCD projector, moderation cards, models and figures). Each didactic session would start with a previously prepared Microsoft Office PowerPoint and video presentations followed by interactive group learning (discussions, case studies, and practical examples). The acquisition of planned knowledge and skills was the

foundation for evaluating the success of each educational module.

Knowledge Assessment and Outcome Measures

Anonymous survey questionnaires in the form of a test to examine the knowledge and attitudes of nurses about CDI and its prevention were designed for the needs of this research based on the modified version of the questionnaire by Brady et al. [38] with additional questions about new prevent and treatment methods e.g. FMT according to the guidelines [6,7].

The knowledge was evaluated using multiple-choice questions with only one correct answer. The tests that were offered to the respondents at the beginning of the educational modules (previous test for evaluation of the baseline knowledge) and at the end of the session (final test to evaluate what was learned) were the same. These tests contained 10-15 questions divided into two parts, the first part: included questions about the social and demographic characteristics of the respondents, the second part: included questions related to the evaluation of knowledge about CDI and its prevention. Tests before and after the educational modules were numbered to correlate with each subject's responses and were not correlated across modules for individual participants. We tested the hypothesis that after the training, the nurses' knowledge about the prevention and control of CDI in hospital settings was significantly higher than the baseline knowledge.

Evaluation of CDI

The diagnosis of CDI is based on clinically identified diarrhoea and laboratory findings. The toxins of *C. difficile* in faeces were identified using laboratory enzyme immunoassays.

Ethical Considerations

The study was performed in accordance with the ethical considerations of the Helsinki Declaration. The study was approved by the Ethics Committee of the University of Banja Luka, Medical Faculty

No: 18/4.4/20. Written consent for was obtained from all the subjects (nurses) who participated in the study. All data collected were confidential and used only by this study.

Statistical analysis

Descriptive statistics and percentages were used to calculate the answers to the questions. A correct answer to each question was graded with "1", and an incorrect answer with "0". The final score of knowledge was obtained by dividing the sum of correct answers by the number of questions, and multiplying the quotient of these two numbers by 10. In that way, it was possible to get a range of scores between 0 and 10. The incidence rate of hospital-associated CDI was calculated as the ratio of the number of infections/10,000 patient days. The incidence defined considering 10,000 according to European Society of Clinical Microbiology and Infectious Diseases (ESCMID) CDI-related guidance documents and the European Centre for Disease Prevention and Control (ECDC) protocol for CDI surveillance in acute care hospitals. Patient-days was calculated by summing the number of days in which a bed is occupied overnight by patients hospitalized during the surveillance period [39]. The level of knowledge before the education was described using Kruskal-Wallis test or one-way analysis of variance (ANOVA). To evaluate the effects of the reality based education program, Wilcoxon rank-sum were used for differences in knowledge before and after the education. Statistical hypotheses were tested at the significance level (alpha) of $p<0.05$. Statistical analysis was done using IBM SPSS Statistics 26 software.

RESULTS

The characteristics of respondents in this study include gender, age, education level and years of experience. The age intervals were defined on the basis of the median value for the age of the respondents. The intervals of years of experience were determined based on the fact that we wanted to show whether the length of years in practice affects knowledge about CDI. The following is the

frequency distribution of the respondents' characteristics in this study:

Demographic	Categories	n (%)
Gender	Male	9 (15)
	Female	51 (85)
Age	19-30	37 (61.7)
	31-60	23 (38.3)
Mean ± SD 31.06±10.74		
Education Level	Secondary School of Nursing	42 (70)
	Bachelor Degree of Nursing	14 (23.3)
	Master's Degree of Nursing	4 (6.7)
Years of Experience	<1	13 (21.7)
	1-15	33 (55)
	>15	14 (23.3)
Mean ± SD 9.00±10.63		

n=number of nurses; SD=standard deviation

Table 1. *Demographic characteristics of study participants*

The research included 12 (20%) nurses working at the ICU, and at clinics for internal medicine, abdominal surgery, infectious diseases and oncology. The majority of interviewed nurses were female - 51 (85%), with an average age of 31.06 ± 10.74 years. The highest percentage of respondents completed secondary medical school (70%) and most of them had professional experience of 1-15 years - 33 (55%) of them (Table 1).

Level of knowledge among participants with various lengths of work in the profession before application of the educational interventions, is presented in table 2:

	Seniority in the Profession	n	Mean	SD	F	df	*p*
CDI knowledge	<1 years	13	4.42	1.41	8.44	2	0.001
	1-15 years	33	4.71	1.32			
	>15 years	14	6.32	1.44			

n=number of nurses; SD=standard deviation; F=F-statistics; *p*=*p* - value

Table 2. *The level of knowledge among participants with various lengths of work in the profession before application of the educational interventions*

Table 2 presents the descriptive statistics of the respondents' baseline, theoretical knowledge before education on CDI in relation to the years of work experience in practice. There was a statistically significant difference (p=0.001) in the evaluation of knowledge in relation to years of experience in practice, meaning that knowledge about CDI was the highest among respondents with >15 years of experience in practice, and the lowest among those who had <1 years of experience.

Level of knowledge among participants with various education levels before application of the educational interventions, can be seen in table 3:

Education levels	**N**	**Knowledge [Points]**					**H**	***p***
		Mean	**SD**	**M**	**Min.**	**Max.**		
High school	42	4.32	1.1 25	4.50	2	6	31.131	<0.001
Bachelor's degree	14	6.43	0.874	6.25	5	8		
Master's degree	4	7.50	1.000	8.00	6	8		

n=number of nurses; SD=standard deviation; M=median; H=Kruskal-Wallis test; p=p-value

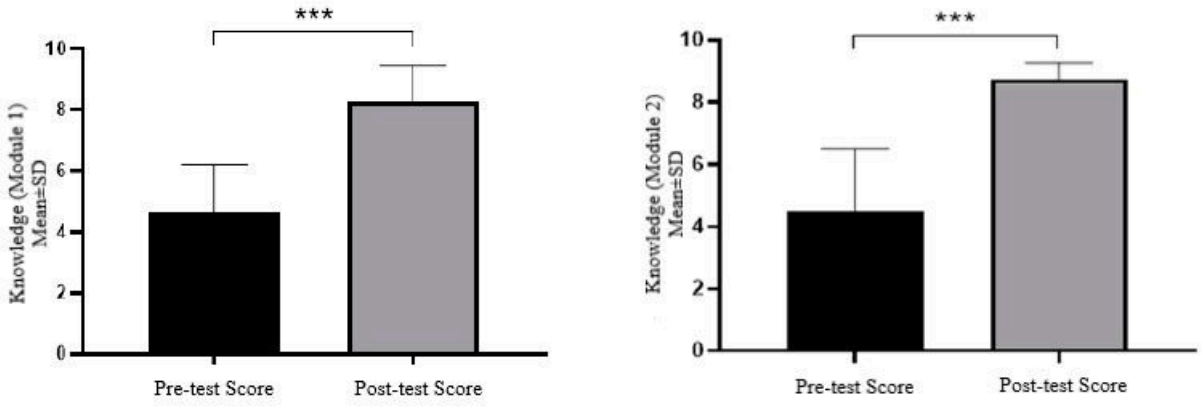
Table 3. *The level of knowledge among participants with various education levels before application of the educational interventions*

We determined a statistically significant difference in the average assessment of knowledge about CDI and the prevention of infections caused by this microorganism, in relation to the level of education (7.5 ± 1.0) (Table 3).

Based on the normality test, the statistical test used for the knowledge is Wilcoxon's matched-pairs test, with the results as shown in the figure 1.

Figure 1 presented the nurses showed highly significant (p<0.001) better knowledge about *C. difficile* and CDI on the Module 1and 2 tests after the education. On the Module 1, the mean value of the total score on the knowledge test about *C. difficile* and CDI was significantly higher after the education (8.29 ± 1.18) compared to mean values of the total score on the test that was performed before the education (5.01 ± 2.00). The mean value of the total score on the CDI prevention

knowledge test was significantly higher after the education (8.70 ± 0.67) compared to the mean values of the total score on the test that was performed before the education (4.5 ± 2.13) (Module 2).



SD=standard deviation; *** p<0.001; Wilcoxon's matched-pairs test

Figure 1. *Mean values of the total score of the Module 1 and 2 tests before and after the education*

CDI incidence before and after the nurses' education on CDI prevention measures, is presented in table 4.

Clinic	Period of examination					
	Before the education			After the education		
	hospital days	Number	%	hospital days	Number	%
Intensive Care Unit	2,666	7	9.5	5,782	7	16.7
Clinic for Internal Diseases	33,994	29	39.2	30,486	18	42.9
Clinic for General and Abdominal Surgery	9,069	1	1.4	8,718	4	9.5
Clinic for Infectious Diseases	8,133	31	41,9	9,859	8	19.0
Clinic for Oncology	13,144	6	8.1	9,896	5	9.5
Total	67,006	74	100.0	64,741	42	100.0
Incidence	11.04/10,000			6.49/10,000		

CDI=*Clostridium difficile* infection

Table 4. *CDI incidence before and after the nurses' education on CDI prevention measures*

Before the education, in the period from 1 July to 31 December 2019, there were 74 patients diagnosed with CDI hospitalised at the UKC RS, whereas after the education of nurses on CDI prevention, in the period from 1 July to 31 December 2020, there were 42 patients diagnosed with CDI hospitalised at the UKC RS. Before the education of nurses on CDI prevention measures, the CDI incidence was 11.04 per 10,000 patient - hospital days. After education on CDI prevention measures, the incidence was 6.49 (Table 4).

DISCUSSION

CDI represents a challenging problem in the acute care environment. Nurses play in important role in the early recognition, diagnosis and rapid treatment of patients with this bacterial infection [40]. Due to the changing epidemiology and increased virulence of *C. difficile*, it was necessary to educate nurses on the implementation of contact prevention measures when in contact with patients with CDI in order to prevent the transmission of *C. difficile* to hospitalised patients, their families, and the nurses themselves. The targeted CDI prevention programme included the development and implementation of an evidence-based protocol [6,7] to improve compliance with prevention measures (hand hygiene, contact isolation, cleaning equipment and surfaces, taking care of patients).

Continuous education of medical staff about CDI represents the foundation in risk management in order to reduce the number of infections, as it enables the transfer of know-how, the development of appropriate procedures and leads to better internal communication. Health care personnel education on CDI could be more important than isolating infected patients in single rooms [41].

The results of this study, the nurses demonstrated better knowledge of *C. difficile*, prevention and control of CDI after the education. Other studies that also evaluated the impact of educational interventions in improving knowledge about infection prevention among nurses had similar results [42-44].

There is evidence to support the fact that both baseline knowledge, and the knowledge gained after an educational intervention on infection prevention, vary with the level of education, type of work, and years of professional experience [22,45]. The results presented here also showed that there is a statistically significant correlation with the level of nurses' education and years of professional experience in relation to the level of knowledge about the prevention and control of CDI.

After reviewing the reference literature, we noticed that the knowledge of health workers about CDI, the ways of transmission and prevention differs between countries. The research conducted in England [46], USA [12,47] and South Africa [48] confirmed that nurses' knowledge about CDI is not satisfactory. The research conducted in Poland demonstrated that despite the average score of 6.85 obtained for correct answers to questions that evaluated the knowledge of medical workers, this value was not satisfactory due to differences in the level of knowledge among different groups. Nurses showed a slightly higher level of knowledge than other health workers [45].

In order to recognize a patient with CDI, healthcare professionals should know how to recognise risk factors, as well as the symptoms present in patients. In the research of Legenza et al. the main barrier in recognising a patient with CDI was insufficient knowledge. Thirteen (50%) participants were not able to describe the risk factors for the occurrence of CDI, which could speed up the diagnosis [48].

The results of the research conducted by Aldeyab et al. [49] provided further evidence that a series of CDI control measures, focusing on risky antibiotics (reduction of quinolone antibiotics), education of staff, patients and their families, implementation of prevention measures and isolation, led to a significant reduction in the incidence of infection in three hospitals in Ireland. The research conducted by Wong-McClure et al. [50] showed similar situation, where infection control strategies implemented proved to be effective in achieving outbreak control and in maintaining the baseline *C. difficile* incidence rate following it.

Even though our educational modules intended for nurses included a part of units which referred to

the use of antimicrobial agents, as the main risk factor for CDI, during the introduction of the protocol the use of high-risk antimicrobial agents was not limited because nurses do not prescribe antibiotics. However, numerous efforts in CDI prevention published in the literature report that antibiotic stewardship programs significantly reduce the incidence of infections and colonization with antibiotic-resistant bacteria and CDI in hospitalised patients [51].

The present study results showed that after educating nurses about CDI prevention measures, the incidence of CDI decreased, but it cannot be claimed that the education itself had an effect on the reduction of this hospital infection. However, some other studies have confirmed that education of nurses about CDI prevention along with control of antibiotic use in patient care can lead to reduction of CDI in acute care hospitals [52-54].

CONCLUSION

The knowledge test on *C. difficile* has confirmed statistically significant differences among nurses, and in prevention and control of CDI after the education compared to the average values of the total score on the test before the education. The study results showed that continuous medical education about CDI can have contribute to inreasing knowledge and awareness about the importance of CDI prevention.

Limitations

This study had several limitations. One limitation of this study is that we recruited nurses from a single hospital and specific findings may only generalize to settings with similar CDI prevention practices and a similar workflow. Consequently, repeated studies using this education program with nurses from other hospitals are needed. The study focuses on both competencies and skills in nurses. The initial plan for our study was to reduction of CDI. During the study, we did not monitor risk factors for CDI such as patient age, severity of the primary disease, and total antibiotic

consumption, which would be necessary for this type of study.

Contact prevention measures, such as the use of personal protective equipment, frequent hand washing and disinfection of surfaces, maintaining distance and isolation of patients have been particularly strengthened since the beginning of the COVID-19 pandemic. It would be good to monitor how well nurses actually practice hand hygiene because epidemiological studies show that most HAI are caused by microorganisms that contaminate the hands of nursing staff. According to some authors, a properly adopted hand washing procedure reduces the risk of CDI infection by half [55]. Additionally, the total sample of subjects included less male persons, which could have influenced the results. However, conducting this type of study can provide guidelines to the hospital infection monitoring and control team so that not only nurses but also other health professionals and persons in charge of hospital hygiene can be educated about CDI in the future. It would be good if this type of CDI education for nurses would be repeated every 6 months and the educational modules are revised according to the new CDI prevention guidelines.

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Conflict of interest

The authors declare no conflict of interest.

Authors' contribution

All authors equally contributed to preparing this article.

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