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RESEARCH ARTICLE

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Prevention of microbial colonization of feeding tubes in the intensive care unit

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Abstract

Background: Various microorganisms which increase the mortality rate in the intensive care unit (ICU) cause microbial colonization of the nasogastric tube (NGT) and use the NGT as a reservoir.

Aim: To detect the colonization on the NGT and to determine the effect that training regarding hand hygiene, NGT management, and enteral feeding (EF) provided to ICU nurses and auxiliary service staff (ASS) has on the level of NGT colonization.

Methods: A quasi-experimental pre-test and post-test control design was used in this study. Microbial samples were taken from the outer and inner parts of NGT. The microorganisms were categorized as: group 1, no risk; group 2, low risk pathogenic; group 3, high-risk pathogenic group. The training was given to nurses ($n = 15$) and ASS ($n = 7$). Hand hygiene, NGT, and EF care training are provided to nurses and ASS by researchers. A total of three training sessions were scheduled to be held in 3 weeks so that all health care staff members were trained. Each session lasted 2 h in total. Patients were assigned to a group if one of the microorganisms presented on the outer surface of the patient's feeding tube and/or on the hub. The hand hygiene

compliance was evaluated by direct observation according to the World Health Organization hand hygiene indications.

Results: The study was conducted with 46 patients. Evaluating the patients for the presence of microorganisms before education revealed that 4.3% were in group 1, 21.8% were in group 2, and 73.9% were in group 3. After the education, evaluating the samples for the presence of microorganisms revealed that 39.1% were in group 1, 13% were in group 2, and 47.8% were in group 3. A statistically significant difference was found between the number of samples included in the groups after the participants had received training ($H = 8.186$; $p = .017$).

Conclusions: An NGT could act as a reservoir of microbial colonization and high-risk microorganisms could be on the tube. Providing training not only to nurses but also to ASS will help reduce the risk of colonization.

Relevance to Clinical Practice: Eliminating such colonization with effective hand hygiene during NGT feeding is a cost-effective method. Providing training not only to nurses but also to ASS will help obtain the optimum benefit from patient care.

KEYWORDS
colonization, enteral feeding, intensive care unit, microorganism, nasogastric tube

1 | INTRODUCTION

Various microorganisms, such as *Methicillin-resistant Staphylococcus aureus*, increase the mortality rate in the intensive care unit (ICU) by 2–2.5 times, causing microbial colonization and contamination of the nasogastric tube (NGT) in ICU patients and use the NGT as a reservoir.[1,2] Contamination of NGTs with these microorganisms can lead to the development of many complications such as abdominal distension, bacteremia, diarrhoea, pneumonia, and even death.[3] Various studies have revealed that bacterial contamination begins 15 min after an NGT is placed with a biofilm developing in 60% of the tubes after 24 h and in all tubes at the end of 48 h.[2,4] The microorganisms that cause contamination of the outer NGT surface have also been found on the inner part of the tube.[5,6]

Health care staff have insufficient knowledge of enteral feeding (EF) and what needs to be considered during the use of the relevant equipment, and this can lead to bacterial contamination.[3,7] The most important risk factor for the transmission of pathogens has been found to be the contaminated hands of health care staff.[8,9] The most effective and cost-effective method to eliminate the colonization and contamination of the NGT is to ensure the compliance of health care staff with hand hygiene procedures.[10,11] However, it is difficult to ensure such compliance in the ICU.[12,13] Health care professionals must take measures to avoid the transfer of microbial growth from hands to patient care items and areas, such as the inner aspect of a feeding tube.[14,15] Infection control education and training in the prevention of infection are vital.[3] Studies have demonstrated that training of staff, correct handling procedures and improved EF protocols can reduce the level and incidence of bacterial contamination in enteral tube feeding.[16]

What is known about this topic

- An nasogastric tube (NGT) could act as a reservoir of microbial colonization and high-risk microorganisms could be on the tube.
- Although NGT is known to be a reservoir for microbial colonization/contamination, relevant studies have focused on the detection and diversity of microorganisms in the paediatric population in intensive care units (ICUs) rather than on effective hand hygiene of health care providers of adult patients in ICUs.

What this paper adds

- This study is the first to evaluate a study group consisting of both nurses and auxiliary service staff (ASS) regarding their compliance with hand hygiene and what to be careful about while caring for patients undergoing enteral feeding (EF) with a nasogastric tube (NGT)
- It was observed in this study that the training on hand hygiene and EF decreased NGT colonization and increased adherence to hand hygiene behaviours in patients receiving EF via NGT
- Providing training not only to nurses but also to ASS will help obtain optimum benefit from patient care.

Some studies have reported that an infection control intervention strategy effectively reduced contamination of feeding tubes and increased hand hygiene.[17]

Some studies have determined the bacterial contamination of the feeding tubes of paediatric ICU patients, who frequently receive enteral nutrition.[18–21] but the number of studies conducted in the adult ICU is more limited.[5,22,23] A relevant study reported that providing training to the health care staff working in the ICU regarding compliance with hand hygiene rules decreases the incidence of NGT contamination.[3] Patchell et al.[24] reported that in 1998 the protocol for EF care decreased EF contamination in 16 paediatric patients who were having EF treatment at home and in hospital. Patchell et al.[24] provided training on the practice of the protocol to ICU workers at the hospital and parents at home. At the end of the study, contamination was decreased both at home and hospital. Given these facts, there was minimal research in which training on hand hygiene and EF care were both provided for eliminating NGT colonization in ICU, not only to nurses but also to auxiliary service staff (ASS). This was the target audience in the present study, and the results were evaluated with reliable assessment tools.

1.1 | Aim of the study

The aim of this study: (1) to detect colonization at the NGT, (2) to determine the effect of the training given to nurses and ASS on the level of knowledge about NGT management and hand hygiene, and (3) to evaluate the effect of training given to nurses and ASS on the level of NGT colonization.

2 | METHODS

2.1 | Study design and participants

A quasi-experimental pre and post-test control design was used in this study. The study was conducted at the 19-bed tertiary anesthesiology and reanimation department ICU of a university hospital between February 2020 and January 2021 in Erzurum, Turkey. Patients aged 18 years or older who had been receiving enteral EF through an NGT for at least three days were included. Infected patients who were undergoing isolation for respiratory, contact or droplet spread, according to the definitions of the American Center for Disease Prevention and Control,[21] were excluded from the study. The patients were receiving intermittent EF treatment at the ICU.

The sampling calculation was performed by using the G*Power 3.1 software program. The records of the ICU where the study was conducted revealed an average of 16 new hospitalizations per month with approximately 10 of these receiving EF. The calculations showed that a sample group of 46 patients would be sufficient, based on the number of microorganisms in the enteral tube before and after training in the study of Ho et al.[3] A total of 22 health care staff members, consisting of 15 nurses and 7 ASS, were working in the ICU at the study period. Routinely in the hospital, ASS for the ICU where the study was conducted received structured theoretical training on specified subjects for two weeks at the hospital from a team of nursing faculty members who were experts on the matter. In the theoretical training, the ASS assisted the nurses in positioning the patient, bathing, bed making and changing the sheets, and cleaning the patient-related devices. After this theoretical training, they participated in practical work, accompanying the intensive care nurses on the specified issues for 1 week under the supervision of a nurse in the ICU. The individuals who were successful in the exam that was performed after the training that took a total of 3 weeks, then started to work in ICU as ASS. The ICU nurses take hand hygiene education periodically three times a year. So, before this study nurses had already received hand hygiene education. Our aim was to reach the entire sample while collecting descriptive data on hand hygiene and EF.

TABLE 1 Classification of microorganisms according to their pathogenicity

Low-risk pathogens ($n = 7$)	High-risk pathogens ($n = 9$)
Candida albicans	*Acinetobacter species*
Enterococcus species	*Citrobacter species*
Escherichia coli	*Enterobacter species*
Haemophilus influenzae	*Klebsiella species*
Moraxella catarhalis	*Morganella species*
Staphylococcus aureus	*Proteus species*
Streptococcus pneumoniae	*Pseudomonas species*
	Serratia species
	Stenotrophomonas species

2.2 | Outcome measures

2.2.1 | Specimen collection

All specimens were collected at the bedside by a microbiologist. In all instances, the administration set tubing was sampled before the hub was sampled. A sterile swab was dipped into a 5-ml tube of brain-heart-infusion (BHI) broth (Becton Dickinson, BBL). Specimens were taken from the outer and inner parts of the NGT. A premoistened swab was inserted approximately 1 cm into the hub of the feeding tube, rotated, removed, and placed into the tube of BHI broth. Specimen swabs were then placed into the tube of BHI broth for transport to the laboratory. The cap of the feeding tube was removed and the hub was sampled as previously described. All specimens were transported to the laboratory and processed immediately on arrival.[3,5,22]

2.2.2 | Microbiological procedures

The samples were incubated in BHI broth at 37°C for 18–24 h and then inoculated on BBL 5% Sheep Blood Agar and BBL Eosin Methylene Blue agar for subculture. The culture plates were left to incubate at 37°C for 48 h in the incubator. The culture plates were checked regularly for growth and colonization at 8-h intervals. The

microorganisms, which were mostly aerobic or facultative aerobic depending on the time the samples were taken, were defined with conventional methods (using some first stage tests such as catalase, oxidase, and gram staining) and the use of the VITEK® 2.0 (bio-Mérieux, Mercy l'Etoile, France) automatic system with various panels developed for the different microorganisms.[3,20,22]

Classification of microorganisms

For the identification of colonies, standard biochemical and microbiologic techniques were used. The identified microorganisms were categorized into three groups according to pathogenicity: group 1, no risk; group 2, low risk pathogenic; group 3, high-risk pathogenic group. The patients were assigned to the relevant risk group if one of the microorganisms presented in Table 1 was found on the outer surface of the patient's feeding tube and/or on the hub.[5] Patients were assigned to the no-risk group if no microorganism grew on the NGT or if the microorganisms that grew were not among those listed in Table 1.[23,25,26]

2.3 | Data collection tools and methods

2.3.1 | Questionnaire form for the identification of participant characteristics

This form was created by the researchers after a literature review.[3,8,13,27–30] The form was used to obtain information on the nurses, ASS, and patients. Questions regarding the health care staff included socio-demographic questions such as age, gender and educational status and the whether they had received training on hand hygiene and EF. Information on the age and gender of the patient, the feeding solution used, and the time the NGT sample was obtained were included in the form (Appendix).

2.3.2 | Questionnaire form for nursing practices regarding EF and hand hygiene

The form created by the researchers after the literature review consisted of nine questions that queried nursing practices regarding NGT, EF, and hand hygiene.[3,5,9,23,27,29–31] It included questions on when nurses should perform hand hygiene, how the EF solution should be stored, and for how long the feeding set should be used (Appendix).

2.3.3 | Hand Hygiene Belief Scale

The Turkish validity and reliability study of the Hand Hygiene Belief Scale (HHBS), originally developed by Van de Mortel[28] in 2000, was conducted by Karadağ et al.[32] This scale consists of 22 items investigating the person's belief in hand hygiene and the perception of the importance of hand hygiene. The scale is scored as follows: 1 = I strongly disagree, 2 = I do not agree, 3 = I am not sure, 4 = I agree, and 5 = I strongly agree. The lowest possible score is 22 and the highest is 110. The Chronbach's α value of the scale is .76. A high score is interpreted as the person having positive beliefs about hand hygiene. The higher the score, the more positive is an individual's beliefs about hand hygiene. For example, a response of strongly agreeing with the statement that 'performing hand hygiene slows down building immunity to disease' indicated a negative belief about hand hygiene. Chronbach's α value in the current study was found to be .72.

2.3.4 | Hand Hygiene Practices Inventory

The Turkish validity and reliability study of the Hand Hygiene Practices Inventory (HHPI), originally developed by Van de Mortel[28] in 2000, was conducted by Karadağ et al.[32] The HHPI is a 5-point Likert-type scale consisting of 14 items. The inventory is scored as follows: 1 = never, 2 = sometimes, 3 = often, 4 = most of the time, and 5 = always. The lowest possible score is 14 and the highest is 70. The Chronbach's α value of the scale is .85. A high score indicates that hand hygiene practices are always followed. Chronbach's α value in the current study was found to be .74.

2.3.5 | Scale For Hand Hygiene Compliance of the ASS

This scale was developed by Özerdoğan and Usta Yeşilbakan[33] to evaluate the compliance with hand hygiene of the ASS employed in the clinics and ICUs. The scale consists of 4 subscales including 'after contact with the patient' (6 items), 'before contact with the patient' (6 items), 'risk of exposure to blood and body fluids' (4 items), and 'after contact with the environment of the patient' (5 items) with a total of 21 items. The five-point Likert type scale is scored as follows: never = 0, sometimes = 1, occasionally = 2, often = 3, always = 4. The lowest possible score is 0 and the highest is 84. A high score indicates a high degree of compliance with hand hygiene practice. The Chronbach's α value of the scale is .86. Chronbach's α value in the current study was found to be .79.

2.3.6 | Hand Hygiene Observation Form

The observation form questions the *My 5 moments for hand hygiene* identified by the World Health Organization (WHO).[29] These are ensuring hand hygiene before contact with the patient, before an aseptic procedure, after contact with body fluids, after contact with the patient, and after contact with the environment of the patient.[29] The observation form was evaluated by direct observation by a nurse who is a member of the infection control committee, who was independent of the study, between 09:00 AM and 4:00 PM on weekdays. Training was given to the nurse about filling the form by the researchers. The observer filled out two forms and researchers

TABLE 2 Timeline of the study and content of the training programme

Date	Content	Nurse	ASS
April–August 2020	Microbial samples were obtained from the feeding tubes of the first 23 patients		
First week of September 2020	Pre-test before training		
Date	**Content**	**Nurse**	**ASS**
First, Second, and Third Week in September 2020	The content of reducing the bacterial colonization on NGT and in EF		
	What is EF?	✓	✓
	Importance of infection control during EF	✓	✓
	Care for EF tubes	✓	
	Contamination of EF system	✓	✓
	Equipments causing contamination in EF	✓	
	Factors causing contamination in EF in bedridden patients	✓	✓
	Disinfection of the administration set	✓	✓
	Importance of hand hygiene (watching video)	✓	✓
	Hand hygiene during patient care	✓	✓
	Hand hygiene during EF		
	Administration of feeds Hands must be washed with liquid soap and warm running water and thoroughly dried with paper towels. Alcohol handrub can be used if hands are visibly clean	✓	
	Cleaning and storage of enteral feeding equipment Wear disposable glove. Cleaning should be carried out in a suitable sink, which is not used for personal care or routine hand hygiene		✓
	Administering medication through an enteral feeding tube Hands should be washed thoroughly with liquid soap and warm running water or an alcohol handrub used before administering medication	✓	
	Care of the tube insertion site Hands should be washed with liquid soap and warm running water and thoroughly dried using paper towels. Alcohol handrub can be used if hands are visibly clean	✓	
	Storage of feeding products	✓	
	Appropriate flushing technique of feeding tube	✓	
	Interactive group activities (question and answer)	✓	✓
Third week of Semptember 2020	Post-test after the training		
October 2020–January 2021	Microbial samples were obtained from the feeding tubes of the second 23 patients		

Abbreviations: ASS, auxiliary service staff; EF, enteral feeding.

checked them. Two forms were filled by the observer. At the beginning of the study, nurses and ASS were informed that they will be assessed at any time without prior notice of the date/time of observation with an observational form whether they were following the five indication rule of WHO.

The hand hygiene practice activity was evaluated in a total of 5 nurses and 3 ASS to include 18 instances in the nurses and 8 in the ASS before the training. The post-training evaluation was conducted on a total of 6 nurses and 3 ASS to include 12 instances in the nurses and 7 in the ASS. Observation results of health workers and ASS also included touching NGTs and nutritional practices. The analyzes also include observation of administration moments, especially before and after holding the NGTs of patients. The formula was used to calculate the Compliance (%) = (Hand Hygiene Activities/Appropriate Times) × 100.[29,34]

2.4 | Data collection process

2.4.1 | Intervention

Step 1: Microbial samples were obtained from the feeding tubes of 23 patients within the scope of the study sample before staff training.

Step 2: After explaining the aim of the study to the nurses and ASS working in the ICU, the Questionnaire Form for the Identification of Participant Characteristics was administered by the researchers with the face-to-face method. The researchers asked the questions to the nurse and ASS and marked the answers. All nurses ($n = 15$) and ASS ($n = 7$) working in the ICU were included in the study. Completing the forms took approximately 5 min.

Step 3: Pre-test was performed before the first training. Hard copies of the questionnaire were disseminated to the nurses and ASS. They

filled out the Questionnaire Form for Nursing Practices Regarding EF and Hand Hygiene, HHBS, HHPI, and Scale For Hand Hygiene Compliance of the ASS. Completing the forms took approximately 20 min.

Step 4: Hand hygiene, NGT, and EF care training provided to ICU nurses and ASS by researchers. The training content was prepared by the researchers and provided by one researcher. One of the researchers was a member of the hospital infection control committee. This researcher nurse is responsible for the training of all staff in the hospital on the prevention of infections, and also has a master's degree. Hand hygiene training prepared in accordance with the 'Guide to the Implementation of the WHO Multimodal Hand Hygiene Improvement Strategy' and training regarding the care of the patient undergoing EF treatment with an NGT were provided to the nurses and ASS by the researchers.[29] Topics related to NGT and EF included (1) What is EF?, (2) Importance of infection control during EF?, (3) Care for EF tubes, (4) Equipment causing contamination in EF, (5) Factors causing contamination in EF, (6) Factors causing contamination in EF in bedridden patients, (7) Disinfection of the administration set, (8) Importance of hand hygiene (watching video), (9) When should hand hygiene be performed during EF?, (10) Hand hygiene during patient care, (11) Storage of feeding products, (12) Appropriate flushing technique of feeding tube, and (13) Interactive group activities (question and answer). The training was given in the seminar room of the ICU at a time suitable for the health care staff. Additional training was organized for the staff who could not participate in the training because of reasons such as time off after being on call, rest period, etc. and a total of three training sessions were scheduled to be held in 3 weeks so that all health care staff members were trained. Each session lasted 2 h in total, and any questions of the health care staff were also answered during this period.

Step 5: After the last training session (third week), the questionnaire forms were distributed and the participants were asked to complete them.

Step 6: Once the training of the health care staff was completed (third week), swab samples were taken from the NGTs of 23 patients who were hospitalized and treated in the ICU (Table 2).

2.5 | Ethical considerations

Approval and permission were obtained from the local ethics committee (date: 11/07/2019, decision no: 24) in addition to the unit and hospital where the study was conducted. All subjects provided informed consent. The same informed consent form was used for nurses, ASS and patients or their relatives. They were informed about the aim of the study and health professionals/patients/patient relatives were asked to sign the form.

2.6 | Data analysis

Data were managed using the IBM SPSS Statistics for Windows, Version 22.0 (SPSS; IBM Corp., Armonk, NY). Compliance with a normal distribution of the measurements obtained within the study was investigated with the Shapiro–Wilk Test. Mean ± standard deviation, median, and interquartile range (IQR) were used to present the descriptive statistics of the continuous numerical variables and number (*n*) and percentage (%) to present the categorical variables. Values not showing normal distribution were compared with the Mann–Whitney *U* Test, Kruskal-Wallis Test, Wilcoxon Signed Test, and Chi-square Test. The Kruskal-Wallis Test was performed to test the significance of differences between more than two groups, using Bonferroni correction to adjust for multiple comparisons. A *p*-value of .05 was accepted as statistically significant. This trial is registered at the ClinicalTrials.gov website.

TABLE 3 Descriptive characteristics of the nurses and auxiliary service staff

	Nurse *n* (%)		Auxiliary service staff *n* (%)	
Age (year)	26 [24–27]		33 [32–42]	
Gender				
Female	10	66.7	-	-
Male	5	33.3	7	100
Education level				
Secondary	-	-	1	14.3
High school	-	-	6	85.7
Vocational school of health	9	60	-	-
University	15	40	-	-
Working time (month)	48 [24–88]		156 [48–240]	
Working time at ICU (month)	24 [20–88]		69 [18–144]	
Working shift				
Daytime	2	13.3	-	-
Daytime + night	13	86.7	7	100
Taking education about hand hygiene periodically				
Yes	11	73.3	7	100
No	4	26.7	-	-

Note: Data were presented as median [IQR] or *n* (%).
Abbreviation: ICU, intensive care unit.

3 | RESULTS

The study was conducted with 46 patients, 15 nurses, and 7 ASS. The median ICU working time was 24 (20–88) months for the nurses and 69 (18–144) months for the ASS. EF training had been previously provided to 73.3% of the nurses before this training, and 20% of the nurses had an intensive care nursing certificate (Table 3).

A statistically significant difference was found between the pre-training and post-training scores of the nurses from the EF questions ($Z = -3.111$; $p = .02$), and the hand hygiene practices inventory score ($Z = -3.411$; $p = .001$), while a similar difference was found for the ASS in the hand hygiene compliance score ($Z = -2.371$; $p = .018$). A

TABLE 4 Knowledge and scales scores among nursing and auxiliary service staff between before and after education

	Before education Median [IQR]	After education Median [IQR]	Z[a]	*p*-value
Number of correct answers about EF	3 [3–4]	5 [4–6]	−3.111	**.02**
Hand hygiene belief scale of nurse	85 [82–89]	84 [79–90]	−0.314	.753
Hand hygiene practices inventory of nurse	45 [44–47]	66 [60–70]	−3.411	**.001**
Hand hygiene compliance of auxiliary service staff	64 [62–67]	83 [78–84]	−2.371	**.018**
Hand hygene compliance of nurse (%)	66.66 [66.66–66.66]	83.33 [66.66–83.33]	−2.911	**.004**
Hand hygene compliance of auxiliary service staff (%)	62.5 [51.38–66.66]	83.33 [72.22–83.33]	−2.536	**.011**

Note: Bold values are statistically significant.
Abbreviation: EF, enteral feeding.
[a]Wilcoxon Signed Ranks Test.

statistically significant increase was also present in the hand hygiene compliance rates of both the nurses ($Z = -2.911$; $p = .004$) and the ASS ($Z = -2.536$; $p = .011$) after the training (Table 4).

Following the training, there was a decrease in the number of microorganisms placed in the high-risk group as a result of the growth of *Acinetobacter, Enterobacter or Klebsiella*, together with an increase in the number of samples with the growth of Serratia. The training also resulted in a decrease in the number of samples placed in the low-risk group because of the growth of *Candida*, *Escherichia coli* or *Enterococcus*. There was no microbial growth in the hub of the NGT in one patient before the training and in three patients after the training (Table S1).

Evaluating the patients for the presence of microorganisms revealed that before education 4.3% were in the no-risk group, 21.8% were in the low-risk group, and 73.9% were in the high-risk group. After the education, evaluating the samples for the presence of microorganisms revealed that 39.1% were in the no-risk group, 13% were in the low-risk group, and 47.8% were in the high-risk group. There was no statistically significant difference between the groups in terms of age, gender, and the duration until swab samples were taken ($p > .05$; Table S2).

The number of samples with microorganisms on NGT increased from one to nine in the group with no risk after education. The samples of number with microorganisms on NGT decreased from five to three in the low-risk group and the number of samples decreased from seventeen to eleven in the high-risk group after education. A statistically significant difference was found between the number of samples included in the groups in terms of having received training ($H = 8.186$; $p = .017$). Post-hoc analysis revealed that the significant difference was caused by the difference between the no-risk and low-risk groups ($p = .043$) and the difference between the no-risk and high-risk groups ($p = .009$; Figure S1).

4 | DISCUSSION

This study has highlighted the importance of the role of the staff's adherence to hand hygiene principles and knowledge of EF care in the microbial colonization reduction of NGT.

Enteral tube feeding has historically been considered a potential source of infection because of the risk of bacterial contamination.[31] The administration of nutritional products and drugs through the NGT and the flushing performed at regular intervals to maintain patency enable microorganisms to enter the digestive system through the tube hub.[5] We found high-risk pathogens such as *Acinetobacter baumannii*, *Klebsiella pneumoniae*, and *Enterobacter aerogenes* on the outer surface of the tube and the hub before the training in this study. In particular, in our study, the number of *A. baumannii* microorganisms was the highest. *A. baumannii* can adhere to the surface of NGT, where it can form biofilms that can migrate from the external to the internal surface of the device, ultimately reaching epithelial cells, where it can cause infection.[35] Similarly, other studies conducted in adult ICUs located in Canada and Netherlands have observed the same microorganisms on the NGT.[5,22,23] *Acinetobacter*, *Klebsiella*, and *Pseudomonas* species can be found on beds, stethoscopes, mechanical ventilators, and other equipment in the ICU.[36] The reason could be the transmission of the microorganisms from patient to patient through the hands of health care staff, as the microorganism can remain on dry surfaces for months. Inadequate hand hygiene before and after entering a patient zone may therefore result in cross-transmission of pathogens and patient colonization.

In this study, the effectiveness of the education was demonstrated by a reduction in the number of patients with microorganisms on the NGT. This result is similar to the limited literature from adult ICUs located in the United Kingdom and nursing home populations in Hong Kong.[3,24] Hand hygiene is a cornerstone of infection prevention. Various studies have revealed microorganisms such as *Enterobacter*, *Klebsieela*, *Enterococcus*, *S. aureus*, *Pseudomonas*, and *E. coli* in the hands of the ICU health care professionals in the USA[37,38] and that the number of these microorganisms could be decreased or eliminated with proper hand hygiene at the studies which were performed in Singapore and the United Kingdom.[39,40] Two factors may explain the high prevalence of *Pseudomonas aeruginosa* on the NGT. One is the lack of mechanical clearance of the mouth provided by chewing and swallowing, an important mechanism in preventing Gram-negative bacteria from colonizing the oropharynx.[41] The second one is *P. aeruginosa*'s known ability to adhere to and form biofilm on plastic

tubes.[41] Training provided to nurses as related to the care of patients undergoing EF treatment is known to decrease the NGT hub contamination rate at the.[3] Although our study was similar to that of Ho et al.,[3] which was carried out at three nursing homes in Hong Kong, as regards the training given on hand hygiene and the care of the patient undergoing EF treatment, we provided training to ASS in addition to the nurses. The ASS helps the nurses during the hygiene and self-care procedures of the ICU patients, moves the necessary devices, and transports the patients. These members of the ICU team should, therefore, also ensure proper hand hygiene during all these procedures. An increase was observed in the hand hygiene compliance of both the nurses and ASS in this study. We believe this was the reason for the significant decrease in the number of patients with microorganisms found on NGTs.

It is widely acknowledged that effective hand hygiene among nurses and other health care personnel is one of the most important infection prevention strategies available.[37] However, low hand hygiene rates in ICUs are a major problem.[42] The Multimodal Hand Hygiene Improvement Strategy and EF training programme applied in this study improved the NGT feeding knowledge and resulted in a decrease in the number of samples with microorganisms on NGT (Table S1). In studies conducted in Hong Kong[3] and the USA,[43] it has been observed that the training provided on hand hygiene, NGT care and decontamination of medical devices reduces the number of microorganisms in patients who receive nutritional therapy with NGT. Compliance rate increased remarkably among nurses and ASS after hand hygiene training in our study and this was also observed in other studies which were carried out at medical, surgical, and coronary ICUs in Argentina, Kuwait, and Iran.[44–46]

4.1 | Strengths and limitations

This study is the first to evaluate a study group consisting of both nurses and ASS regarding their compliance with hand hygiene and what to be careful about while caring for patients undergoing EF with an NGT, and where training was provided to both groups. A training program prepared by including the steps of the 'Guide to the Implementation of the WHO Multimodal Hand Hygiene Improvement Strategy' with a structured program was implemented. Compliance with hand hygiene was monitored objectively by a nurse who was independent of the study, and the observation form was completed according to the framework of the *My 5 moments identified by the WHO*. Although the NGT is known to be a reservoir for microbial colonization/contamination, the relevant studies have often been conducted in a paediatric population. This study is an addition to the limited number conducted in adult ICUs, and it is the first to take place in our country in this sense. Our study had some limitations. First, the results of the study are limited to the patients receiving intermittent EF treatment at the adult ICU where the study was conducted. Secondly, the study was conducted in a single unit with limited number of staff included in the sample. Thirdly, the contamination rate of the NGTs with the microorganisms was not calculated. Lack of randomization of the intervention is the last limitation of this study.

5 | IMPLICATIONS AND RECOMMENDATIONS FOR PRACTICE

Eliminating such colonization with effective hand hygiene and compliance with the strategic patient care principles (training about: (1) compliance of hand hygiene and (2) the content of reducing the bacterial colonization on NGT and in the EF system) during NGT feeding is also an effective method. Providing training not only to nurses but also to ASS will help obtain the optimum benefit from patient care. We recommend conducting future studies on patient feeding tube contamination with larger sample groups undergoing EF treatment with continuous or bolus methods in addition to intermittent feeding.

6 | CONCLUSION

This study has shown the effectiveness of an education program in reducing the risk of microbial transmission, and the need for better training of staff performing EF in the ICU. The infection prevention and control intervention strategies (hand hygiene and EF system care) effectively reduced microbial transmission of NGT and increased hand hygiene. The intervention strategies can be implemented to prevent the occurrence of microorganisms on NGT.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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