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Effects of Training on High Flow Nasal Cannula Oxygen Therapy on Pediatric Nurses' Knowledge Levels: A Randomized Controlled Study

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Abstract

Background: High-flow nasal cannula (HFNC) is a safe and effective form of noninvasive ventilation for children with respiratory distress. Pediatric high-flow nasal cannula has been successfully implemented in resource-limited settings; however, little is known about the nursing training required to integrate HFNC into care.

Aim: This study aimed to investigate the effect of training on nurses' knowledge levels regarding HFNC oxygen therapy.

Methods: This randomized, controlled, experimental study was registered on clinicaltrials.gov under registration number NCT05362279. The study was conducted with 70 nurses working in the pediatric clinics of a public hospital between December 2021 and May 2022. Half of the nurses were assigned to the experimental group (n=35) and the other half to the control group (n=35). Two data collection tools were used: the Sociodemographic Characteristics Questionnaire and the High Flow Nasal Cannula Oxygen Therapy Questionnaire. The nurses in the experimental group received training immediately after the pre-test. The training lasted about an hour, and the posttest was administered one month after the training. Descriptive analysis was performed, and the study data were analyzed. Because they were not normally distributed, the Mann-Whitney U test, Kruskal-Wallis test, and Wilcoxon test were used for data analysis. A *p*-value of <0.05 was considered statistically significant.

Results: There was no significant difference between the nurses in the experimental and control groups regarding age, sex, education level, length of service in the profession, length of service in the current clinic, the clinic they worked in, and previous training on oxygen administration. The median posttest knowledge score of the nurses in the experimental group increased after the training. While there was no difference between the pretest scores of the nurses in the experimental and control groups, there was a significant difference between their posttest scores.

Conclusion: The training given to the nurses increased their knowledge levels about high-flow nasal cannula oxygen therapy. Providing such training to nurses can help eliminate their knowledge gaps in clinical practice.

Keywords: High flow-nasal cannula, education, knowledge, noninvasive ventilation

Introduction

High Flow Nasal Cannula Oxygen Therapy (HFNC) is a noninvasive ventilation system that enables the delivery of heated and humidified oxygen at varying flows to the patient with the help of a nasal cannula.[1] Although HFNC systems differ from one manufacturer to another, they generally consist of the same components, such as a patient-sized nasal cannula, sterile water tank, oxygen-air blender, heated and insulated circuit providing air, and air humidifier.[2,3] HFNC has several benefits over traditional oxygen delivery systems, including washing the nasopharyngeal dead space, warming and humidifying the air under appropriate conditions, reducing inspiratory resistance and respiratory workload, improving airway conduction and compliance, providing a positive end-expiratory pressure (PEEP) effect, and delivering a constant fraction of inspired oxygen (FiO_2).[3-6] HFNC was originally started as an alternative respiratory support to nasal continuous positive airway pressure (CPAP) in premature infants. It has since been increasingly used in patients with respiratory distress.[3] The patient group with the highest level of evidence for HFNC consists of those with moderate to severe bronchiolitis.[7,8] Although its use has steadily increased in recent years, there is an accepted guideline on indications, contraindications, and flow rates regarding HFNC.[9]

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However, each unit implements HFNC by interpreting their own experiences. The literature states that in most hospitals, HFNC is implemented in intensive care units (ICUs); however, the rate of implementing HFNC in units other than ICUs is low.[10] The low clinical popularity of HFNC in units other than ICUs is probably due to the fact that clinicians know little about HFNC technology and cannot implement HFNC independently and safely in the clinic.[11] Various studies have been conducted on how nurses implement HFNC.[12-16] In these studies, the following topics have been discussed: nurses' implementation of HFNC and its advantages,[13,14,17] differences between physicians and nurses regarding the implementation of HFNC,[18] implementation of HFNC in newborns at different gestational weeks,[16] nutritional status of the patient during treatment[12] and nurse-patient ratios.[15] All these studies' results indicate that nurses play an important role in the safe and effective implementation of HFNC. Clinical guidelines on the implementation of HFNC including flow settings, indications, contraindications, device management and effective use, particularly in children, should be developed.[19] The implementation of HFNC in units other than ICUs in Türkiye, has increased recent years. The present study was carried out to investigate the effect of training on high-flow nasal cannula oxygen therapy on nurses' knowledge levels. Therefore, the present study is expected to improve nurses' knowledge and awareness of HFNC and to provide a data source for future studies.

Hypotheses of the Study

H0: There is no difference between the pretest and posttest knowledge scores of nurses in the experimental and control groups.

H1: There is a difference between the pretest and posttest knowledge scores of nurses in the experimental and control groups.

Materials and Methods

Design and Participants

This randomized, controlled, experimental study was registered on clinicaltrials.gov under registration number NCT05362279.

Study Setting and Sample

The study was conducted between December 2021 and May 2022 in the infant, pediatric emergency, and pediatric internal medicine clinics of a university hospital, where the implementation of HFNC was most frequently used. In these clinics, pediatric patients with respiratory distress are hospitalized and followed up, and the patient group undergoing HFNC is cared for, treated, and followed up most. The population of the study consisted of 76 nurses who met the inclusion criteria. Nurses who worked in the pediatric emergency, infant, and pediatric internal medicine clinics, who did not receive training on the implementation of HFNC, who gave care to at least one patient having undergone HFNC in the clinics, and who volunteered to participate in the study were included in the study. Of the nurses in the study population, those who received in-service training on the implementation of HFNC, those who worked as charge nurse or training nurse in the clinics where the research was conducted, and those who filled in the data collection forms incompletely or withdrew from the study at any stage of the study were excluded from the study. At the end of the study, "post hoc" power analysis was performed to evaluate whether the sample was sufficient. The effect value of the study was calculated as 0.5 and the result of the "post hoc" power analysis performed by taking $\dot{\alpha}$=0.05 was found to be 0.78. It is appropriately indicated that the power is between 0.70-0.90.[20] The study sample is shown in Figure 1 in the Flow Chart of the study.

Randomization and Blinding

Randomization

Nurses were stratified into five groups according to their years of work in the profession (less than 1 year, 13 months-2 years, 3-5 years, 6-9 years, and over 9 years). After stratification, the nurses were assigned to the experimental and control groups using the simple random sampling method via the random.org site.

Blinding

Nurses and researchers were not blinded in this study.

Data Tool

In the study, two data collection tools were used: the Sociodemographic Characteristics Questionnaire and the HFNC Questionnaire. The Sociodemographic Characteristics Questionnaire contains seven items questioning the participating nurses' age, sex, clinic they work in, length of service in the profession, length of service in the current clinic, and educational status. It also inquires whether they had previous training on oxygen administration. The HFNC questionnaire contains 17 items questioning the patient group undergoing HFNC, flow and FiO_2 values, advantages and disadvantages of HFNC, nutritional status of the patients, and the setup and mechanism of the device.

The questions were prepared according to the literature,[12,13,15,17,18] and then the form was finalized by obtaining expert opinions from four health professionals: two emergency medicine specialists (doctors), one pediatric intensive care specialist (doctor), and one pediatric intensive care nurse. The Kuder-Richardson value was checked for the validity of the HFNC Questionnaire and was found to be 0.853. Of the items, seven were true-false type questions and ten were multiple-choice questions. Correct answers were given 1 point, while wrong answers were given 0 points. The highest possible score on the questionnaire is 17. An increase in the score indicates a higher level of knowledge. Scores of 0-5 points were determined as "low level of knowledge," 6-11 points as "medium level of knowledge," and 12-17 points as "high level of knowledge".

Data Collection

In the study, data from the control group were collected first, followed by data from the experimental group, both before and after the training.

Intervention

The Sociodemographic Characteristics Questionnaire and HFNC Questionnaire were administered to the nurses in the control group as a pre-test, and one month later, the HFNC Questionnaire was administered again as a post-test. After collecting data from the control group, the nurses in the experimental group were given the Sociodemographic Characteristics Questionnaire and HFNC Questionnaire as a pre-test. Following the pre-test, they received training on HFNC. One month after the training, they completed the HFNC Questionnaire again. The training content on HFNC included the definition of HFNC, diseases for which it is used, FiO_2, flow rate, advantages and disadvantages of HFNC, the mechanism and

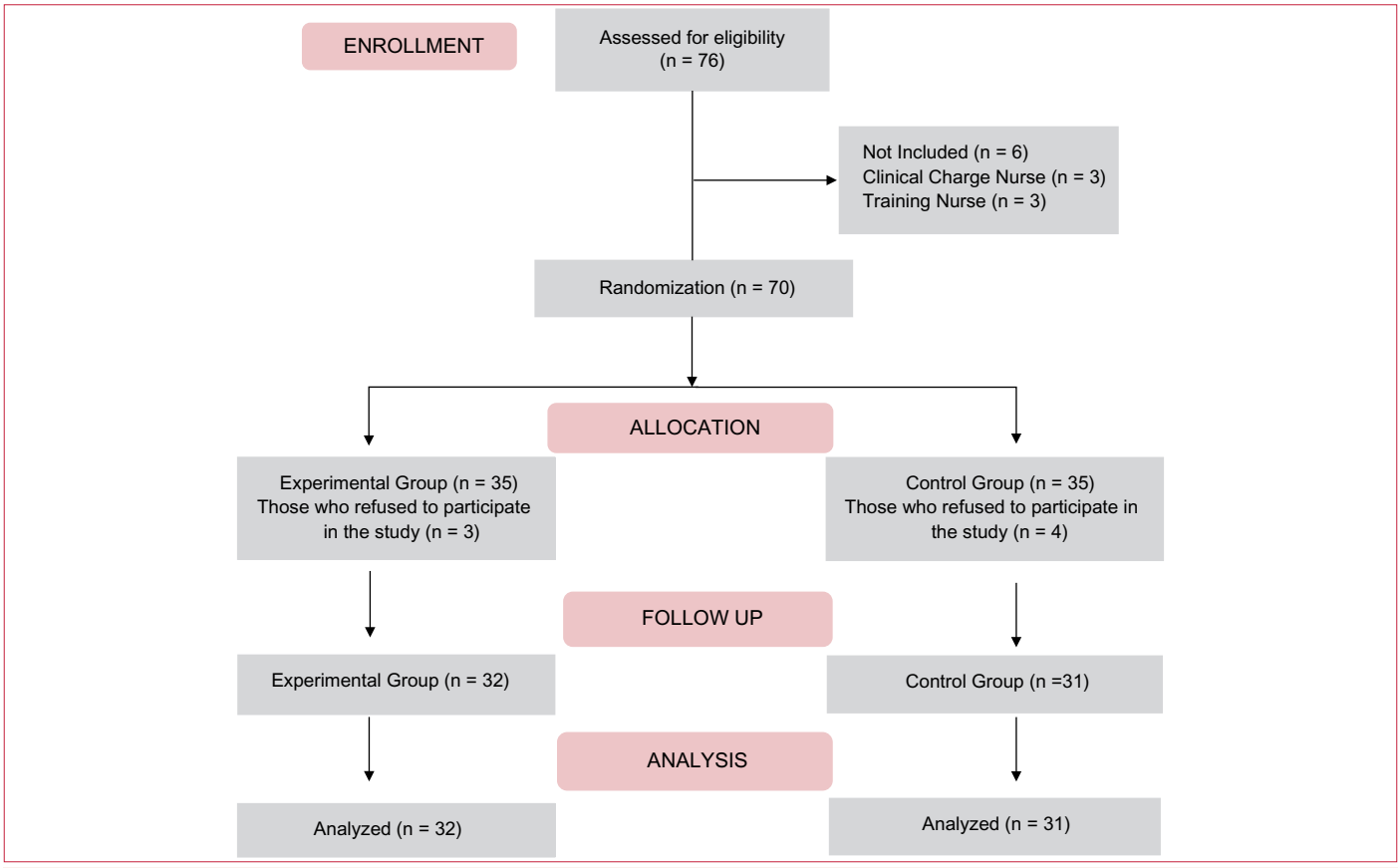

Figure 1. Flow chart of the Study.

installation of the device used for HFNC, and the evaluation of its effectiveness in patients. Because the nurses in the experimental group worked in different clinics and had 24-hour shifts due to the COVID-19 pandemic, groups were formed considering their working conditions. Each group included a maximum of five nurses. The training was given as a PowerPoint presentation by the first researcher in the clinic's meeting room using a computer and a mirroring device. The training lasted about an hour. The training was conducted at times suitable for the intensity of the clinics and the nurses' working hours. After the PowerPoint presentation, the installation and equipment of the HFNC device were demonstrated to each nurse, and they were given time to practice. After the study data were collected, nurses in the control group also received training on HFNC.

In the study, control group data were first collected using the stepped wedge method. Nurses were asked to provide a code to ensure the confidentiality of the study. They were instructed to answer the questions using this code.

Statistical Analysis

Statistical analysis was done using the Statistical Package for Social Sciences (SPSS) (IBM Statistical Package for the Social Sciences Inc., version 25.0, PA, USA) software. An independent statistician performed the data analysis for this study. Descriptive analysis (arithmetic mean, standard deviation, median, frequency, rate, minimum, and maximum values) was performed on the study data. Shapiro-Wilk/Kolmogorov-Smirnov tests were conducted to determine whether the quantitative data were normally distributed. Because they were not normally distributed, the Mann-Whitney U test was used, and Kruskal-Wallis test was used to compare three or more groups. The Wilcoxon test was used for intra-group comparisons in dependent groups. A p-value of less than 0.05 was considered statistically significant. The primary outcome criterion in the study was the increase in the knowledge level of nurses through the training given to them.

Ethical Considerations

Before the study was conducted, ethical approval was obtained from A University Hospital Health Sciences University Non-Interventional Research Ethics Committee (Approval Number: 2022/10, Date: 18.01.2022) and institutional permission (Decision No: 0504) was obtained from the management of a university hospital affiliated with the University of Health Sciences where the study was to be conducted. Depending on the type of study, written or verbal consent is sufficient. Verbal consent was obtained from the nurses participating in the study.

Results

There was no significant difference between the nurses in the experimental and control groups in terms of variables such as age, sex, education level, length of service in the profession, length of service in the current clinic, the clinic they worked in, and previous training

on oxygen administration (Table 1). In other words, the groups had similar sociodemographic and work-related characteristics (P > 0.05).

The comparison of the distribution of the correct answers given to the questions in the HFNC Questionnaire at the pre- and post-tests of the nurses in the experimental and control groups is shown in Table 2. The percentages of correct answers given by the nurses in the control group at the pre- and post-tests were close to each other. However, the percentages of correct answers given to questions about the mechanism of HFNC, application areas, description, termination, and complications in the HFNC questionnaire at the pre-test by the nurses in the control group increased at the post-test. The comparison of intra-group median scores obtained from the High Flow Nasal Cannula Oxygen Therapy Questionnaire at the pre- and post-tests given during the training of the nurses in the experimental and control groups is shown in Table 3. The median knowledge scores of the nurses in the experimental and control groups at the pre-test were 11.0 and 12.00, respectively. The Mann-Whitney U analysis revealed that there was no significant difference between the experimental and control groups in terms of their pre-test knowledge scores (P = 0.137). The median knowledge scores of the nurses in the experimental group at the pre- and post-tests were 11.0 and 16.00, respectively. The Mann-Whitney U analysis revealed that there was a statistically significant relationship between their pre- and post-test knowledge scores. The median knowledge scores of the nurses in the experimental and control groups at the post-test were 16.0 and 11.00, respectively. The Wilcoxon analysis revealed that there was a significant difference between the experimental and control groups in terms of their post-test knowledge scores (P = 0.000).

Table 1. Comparison of Sociodemographic Characteristics of the Participants

Characteristics		Control Group Mean ± SD		Experimental Group Mean ± SD		Analysis
Age		30.35 ± 7.13 **Min-max** =23-44		30.97 ± 6.74 **Min-max**= 24-45		KW= .933 P= .334
		n	**%**	**n**	**%**	χ^2= .997 P=.318
Sex	*Women*	23	74.2	27	84.4	
	Men	8	25.8	5	15.6	
Educational status	*High school*	3	9.7	1	3.1	χ^2= 1.149 P=.765
	Associate degree	8	25.8	9	28.1	
	Undergraduate	18	58.1	20	62.5	
	Postgraduate	2	6.5	2	6.3	
Length of service in the profession	*<1 year*	-	-	-	-	χ^2= .221 P=.974
	1-5 years	14	45.2	15	46.9	
	6-10 years	6	19.4	5	15.6	
	11-15 years	4	12.9	5	15.6	
	>15 years	7	22.6	7	21.9	
Length of service in the current clinic	*<1 year*	4	12.9	2	6.3	χ^2= 1.118 P=.773
	1-5 years	18	58.1	22	68.8	
	6-10 years	8	25.8	7	21.9	
	11-15 years	1	3.2	1	3.1	
	>15 years	-	-	-	-	
Clinic worked in	*Pediatric emergency department*	18	58.1	19	59.4	χ^2= .630 P=.730
	Infant clinic	6	19.4	8	25.0	
	*Pediatric Internal Medicine Clinics**	7	22.6	5	15.6	
Having received training on oxygen therapy and applications	*Yes***	9	29.0	13	40.6	χ^2= .931 P=.335
	No	22	71.0	19	59.4	
Total		31	100	32	100	

**Pediatric Internal Medicine Clinics: Pediatric Neurology Clinic - Pediatric Endocrine Clinic - Pediatric Cardiology Clinic - Pediatric Allergy Clinic - Pediatric Nephrology Clinic - Pediatric Infection Clinic.*
***Training Content includes Oxygen Applications and Nursing Interventions.*
KW: Kruskal Wallis Test χ^2: Chi-Square Test

Table 2. Distribution of the Correct Answers Given to the Questions in the HFNC Questionnaire by the Participating Nurses at the Pre- and Post-tests

	Experimental Group				Control Group			
	Pre-test		Post-test		Pre-test		Post-test	
Questions	n	%	n	%	n	%	n	%
Question 1 Description of HFNC	30	93.8	32	100.0	31	100.0	31	100.0
Question 2 Description of HFNC	12	37.5	32	100.0	14	54.8	18	58.1
Question 3 Mechanism of HFNC	30	93.8	32	100.0	28	90.3	28	90.3
Question 4 Application areas of HFNC	17	53.1	29	90.6	6	19.4	10	32.3
Question 5 Mechanism of HFNC	30	93.8	32	100.0	28	90.3	30	96.8
Question 6 Application areas of HFNC	26	81.3	32	100.0	29	93.5	23	74.2
Question 7 Patient nutrition during HFNC	6	18.8	28	87.5	10	32.3	8	25.8
Question 8 Equipment for HFNC	18	56.3	17	53.1	16	51.6	13	41.9
Question 9 Mechanism of HFNC	7	21.9	29	90.6	6	19.4	10	32.3
Question 10 Equipment for HFNC	30	93.8	32	100.0	30	96.8	30	96.8
Question 11 Application areas of HFNC	30	93.8	32	100.0	29	93.5	30	96.8
Question 12 Termination of HFNC	23	71.9	30	93.8	24	77.4	27	87.1
Question 13 Patient nutrition during HFNC	10	31.3	28	87.5	14	45.2	14	45.2
Question 14 Success indicators HFNC	31	96.9	32	100.0	27	87.1	27	87.1
Question 15 Fio_2 concentration	5	15.6	25	78.1	8	25.8	8	25.8
Question 16 Complications of HFNC	9	28.1	30	93.8	9	29.0	14	45.2
Question 17 Advantages of HFNC	29	90.6	32	100.0	25	80.6	23	74.2

Discussion

In the present study, there was no difference between the pre-test scores of the nurses in the experimental and control groups, but there was a difference between their post-test scores. Intra-group analysis demonstrated that while there was no difference between the pre- and post-test scores of the nurses in the control group, there was a significant difference between the pre- and post-test scores of the nurses in the experimental group. Studies on HFNC have generally been conducted in intensive care or emergency units.[12,16,18] In a study that evaluated the protocol established for the implementation of HFNC in units other than ICUs and the effectiveness of the training given, it was observed that HFNC could be implemented safely in units other than ICUs if appropriate patients were selected and personnel were trained.[21]

The rate of correct answers by nurses in the experimental and control groups to questions about the HFNC device and the equipment used in the pre-test and post-test is over 40%. Although the nurses did not receive formal training beforehand, it was observed that they were knowledgeable about the installation and equipment of the HFNC device because they had been using these devices in their clinics for

Table 3. Distribution of Intra-Group Median Scores obtained from the High Flow Nasal Cannula Oxygen Therapy Questionnaire at the Pre- and Post-Tests Given during the Training

	Pretest		Posttest		
Groups	Median	Min-max	Median	Min-max	Analysis*
Experimental Group	11.00	7.00-16.00	16.00	14.00-17.00	Z:-4.806 **P=0.000**
Control Group	12.00	7.00-15.00	11.00	8.00-15.00	Z: -.790 **P=0.429**
	Difference between Pretest Scores of the Groups U: 389.000 P=.137		Difference between Posttest Scores of the Groups U:11.000 **P=.000**		

**Intra-group analysis U: Mann-Whitney U test; Z: Wilcoxon signed rank*

a long time. Wen et al. stated that bedside nurses should be given training courses on HFNC, with more emphasis on monitoring and procedures of HFNC, and especially nurses should be trained on standardized protocols for the installation, use, and disinfection of HFNC devices.[22] Training nurses on the installation and use of the HFNC device and standardizing this training will enable better treatment and care of patients.

In the present study, the questions about the nutrition of the patients who were administered HFNC were answered least correctly by the nurses in the experimental and control groups at the pre-test. The nurses' knowledge level about nutrition was insufficient, not only due to the lack of protocols regarding the nutrition of patients receiving HFNC in the three different clinics during their treatment but also due to differences in clinical practices. The literature states that continuing enteral feeding in critically ill children has clinical benefits and improves morbidity and mortality. However, it has been reported that clinicians are reluctant to continue feeding infants with bronchiolitis while providing HFNC to the infants.[23] Rice et al. stated that clinicians should be careful while feeding patients receiving HFNC, consider patient-specific factors when making decisions, and conduct clinical studies to develop guidelines on oral nutrition and to obtain definitive results.[24] There are different approaches in the literature regarding the nutrition of patients during HFNC follow-up. It is thought that creating a nutrition protocol in the clinics where the research is conducted and making decisions based on the patient would be a more accurate method.

In the pre-test, the rate of correct answers given to the FiO_2 concentration question by the nurses in the experimental and control groups was low. It was observed that they were not knowledgeable enough about the accuracy of the FiO_2 concentration in the HFNC device. Wen et al. revealed that FiO_2 was the parameter that showed the best HFNC performance and that it was important to set the flow rate correctly.[22] They also stated that HFNC flow rate was the parameter that directly affected patient comfort.[22] HFNC has been one of the non-invasive ventilation applications frequently performed, especially in patients with COVID-19. It should be performed in environments where the nurse-patient ratio is high because it requires continuous observation. It has been stated that new nurses or nurses working in units other than intensive care units should be trained in patient care which requires a device, equipment, and respiratory support, and that these patients should be followed up with continuous pulse oximetry, hourly vital signs, neurological symptoms, and an early warning score.[25] Parameters such as FiO_2 concentration and flow rate are decided by doctors in the clinics where the study is conducted. It is thought that this is the reason for nurses' lack of knowledge on this subject.

Strengths of the Study

The research is the first study in Türkiye to examine the effectiveness of training given to nurses regarding high-flow nasal cannula oxygen therapy. Nurses in the clinic where the study was conducted are involved in the installation of the HFNC device and patient follow-up.

The nurses participating in the study were informed about the mechanism of action, indications, and contraindications of high-flow nasal cannula oxygen therapy.

Limitations of the Study

The study has some limitations. First, the study was conducted in a public hospital where the number of clinics in which HFNC was performed was limited. The second limitation is that the training provided could not assess the HFNC practice skills of the nurses, nor whether the nurses who received training applied HFNC correctly.

Conclusion

The training provided to the nurses enhanced their understanding of high-flow nasal cannula (HFNC) oxygen therapy. Such training can help bridge knowledge gaps in clinical practice. We recommend that nursing protocols be created by planning studies on different samples for care practices, and nursing roles and tasks regarding HFNC.

Ethics Committee Approval: Ethical approval was obtained from A University Hospital Health Sciences University Non-Interventional Research Ethics Committee (Approval Number: 2022/10, Date: 18.01.2022) and A Training and Research Hospital (Decision No: 0504).

Informed Consent: Verbal consent was obtained from the nurses participating in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – A.A.; Design – A.A., M.Y.; Supervision – A.A.; Resource – A.A.; Materials – A.A.; Data Collection and/or Processing – A.A., H.Y.S., M.Y.; Analysis and/or Interpretation – A.A., H.Y.S., M.Y.; Literature Review – A.A.; Writing – A.A., H.Y.S.; Critical Review – A.A., H.Y.S.

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