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Effect of evidence-based infection prevention and control guidelines on pediatric nurses' practices in neonatal intensive care units

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Abstract: Background: Infection control is essentially a clinical service directly related to improving and maintaining the quality of patient care. **Aim**: To determine the effect of evidence-based infection control guidelines on pediatric nurses' practices in the neonatal intensive care unit (NICU)**. Research design:** A pre/post quasi-experimental research design was utilized to meet the aims of this study. This study was performed at Qena University Hospital in neonatal intensive care units using a convenience sample of 30 nurses. An educational program for nurses was created using the following data collection tools: 1) socio-demographic data, 2) observation guidelines, and 3) an educational training practice program. **Results:** There was a significant increase in the mean total performance scores after one month of the program (119.20 ± 6.14) compared with the mean scores before program initiation (82.07 ± 8.95) ($p < 0.001$). **Conclusion**: Infection prevention and control practices of pediatric nurses can be improved by implementing evidence-based infection prevention and control guidelines. **Recommendations:** Regular training sessions and workshops on infection prevention and control guidelines in NICUs should be organized by official institutions for nurses and health team members.

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1. Introduction:

Infection prevention and control practices can be improved by the implementation of evidence-based infection prevention and control guidelines (**Buchan et al., 2010)**. These clinical guidelines serve various purposes including improving the effectiveness and quality of care, reducing variations in healthcare practices, and decreasing costly and avoidable adverse events (**Kredo et al., 2016).**

Preterm infants and critically ill neonates are at high risk for late-onset nosocomial infections because of their immature immune system, ineffective mucosal barriers, and the need for invasive devices (**Ramasethu 2017; Collinset al., 2018; Jong et al., 2017)**. The risk of late-onset nosocomial infections increases with lower birth weight and lower gestational age.

Newborn care and neonatal sepsis are major challenges. The lack of infection prevention antepartum and intrapartum, overcrowding, poor hand hygiene, and the use of invasive devices for ventilatory support and vascular access contribute to the high rates of infections in newborns and particularly in premature infants **(Delhi Neonatal Infection Study, 2016)**.

In the neonatal intensive care unit (NICU), central lines are essential for the care of critically ill neonates to provide lifesaving medications, total parenteral nutrition, and access for hemodynamic surveillance **(Kulali et al., 2019; Zhou et al., 2015).** However, the use and duration of central lines are considered independent risk factors for central line-associated bloodstream infections in preterm infants **(Payne et al., 2018; Salm et al., 2016).**

Despite preventative measures, central venous catheter-related infections are common, with rates of 0.5–2.8/1000 catheter days in children and 0.6–2.5/1000 catheter days in neonates. Central line infections in children are associated with increased mortality, an increased length of hospital and intensive care unit stay, treatment interruptions, and increased complications. Prevention is paramount and involves a variety of measures including tunneling of long-term devices, chlorhexidine antisepsis, maximum sterile barriers, aseptic non-touch technique, minimal line

accessing, and evidence-based care bundles (**Chesshyre et al., 2015).**

Patients in the NICU are at an increased risk for central line-associated bloodstream infections because they have more severe health conditions and require the use of central lines for long periods of time (**Taylor et al., 2017; Tarr & Warner 2016).** To prevent central line-associated bloodstream infections, hospitals often implement patient safety initiatives that standardize central line insertion and maintenance practices via "care bundles" (**Payne et al., 2018).**

Nurses constitute the largest percentage of the health care workers (HCWs) and serve as the "nucleus of the health care system." Because they spend more time with patients than any other HCWs, their compliance with hand washing guidelines seems to be more vital in preventing disease transmission among patients (**Nair et al., 2014).**

Shinde & Mohite (2014) reported the urgent need for introducing measures to increase the knowledge, attitudes, and practices of staff in teaching hospitals, which may play a very important role in increasing hand hygiene compliance among the staff and reducing cross transmission of infections among patients.

Significance of the study

There is a higher incidence of infections in NICUs than in other ICUs because of the unique vulnerabilities of neonates and the environmental risk factors specific to NICUs. NICUs have a reported incidence of 1.7 million infections annually, resulting in approximately 99,000 deaths and severe morbidity; furthermore, 33,000 infants are diagnosed with hospital-acquired infections (HAIs) each year in NICUs. Central line-associated bloodstream infections, ventilator-associated pneumonia, catheter-associated urinary track infection, and surgical site infection have incidence rates of 4.7/1000 catheter days (95% CI: 2.9–6.5), 14.7/1000 ventilator days (95% CI: 11.7–17.7), 8.9/1000 catheter days (95% CI: 6.2–11.7), and 7.8% (95% CI: 6.3–9.3%), respectively (**Ling, 2015)**.

Nosocomial infection surveillance in an Egyptian NICU showed that of the 238 neonates evaluated, 49 developed 51 nosocomial infective episodes, equating to an incidence rate of 21.4% or 13.8 infections per 1000 bed-days. Pneumonia was the most frequently occurring infection (11.3%), followed by bloodstream infections (8.8%). The most frequently isolated organisms were *Klebsiella* spp. (33.3%), followed by *Escherichia coli* (21.6%). Nosocomial infections were associated with prolonged hospital stay (**Abdel-Wahab et al. 2012)**. In view of the limited literature and studies on the prevention and control of infections in NICUs, this study was conducted in a NICU in Qena University Hospital (first study conducted in this hospital) to assess infection control measures and how to prevent such infections.

Aims of the study: This study aimed to:

1. Assess pediatric nurses' practices in the NICU before applying evidence-based infection prevention and control guidelines
2. Apply the evidence-based infection prevention and control guidelines to pediatric nurses in the NICU
3. Evaluate the effect of the evidence-based infection control guidelines on pediatric nurses' practices in the NICU

Research hypotheses

Infection prevention and control practices can be improved by implementing evidence-based infection prevention and control guidelines.

Research design

A pre/post quasi-experimental research design was utilized to meet the aims of this study.

Subjects

The study population consisted of a convenience sample of 30 nurses from Qena University Hospital who worked in the NICU.

Setting (place of the study)

This study was conducted at the NICU of Qena University Hospital. The NICU is located on the first floor and contains two rooms; the first room is for septic cases and has a capacity of 6 incubators whereas the second room is for clean cases and has a capacity of 24 incubators. The NICU is staffed by 30 nurses, and the estimated nurse/patient ratio is 1 to 1.

Data collection tools

Tool I: Tool I was comprised of socio-demographic data including age, marital status, educational level, and career period of the nurses.

Tool II: Tool II was comprised of observation guidelines (pre- and post-test) that were used to assess the nurses' practices regarding infection prevention and control. The following aspects were evaluated: intravenous (IV) cannula insertion (**9** steps), the preparation of IV fluids (**20** steps), the use of a multi-dose vial/ampoule (**11** steps), and the administration of IV medications with IV fluids (**15** steps) (**Soliman, 2009; WHO, 2016)**. Furthermore, the nurses' practices regarding umbilical catheter site care (**12** items); skin care (**11** items); eye care (**2** items); infant breast feeding (**13** items); artificial feeding (**6** items); and standard precautions for infection control (hand washing, personal protective gloves, gown and sterile instruments and devices; **17, 18, 4,** and **7** items, respectively); were evaluated (**Soliman, 2009).**

Scoring system

The practices that were correctly performed received a score of 1 and those that were incorrectly performed received a score of 0. The maximum possible score was 145 and the minimum was 0.

Validity:

The face validity of the tool was assessed through review by three experts in the pediatric nursing and medicine specialties (the questionnaire and the observation checklists were evaluated).

Reliability:

The reliability coefficients for the questionnaire, observation checklist I, and observation checklist II were 0.81, 0.99, and 1, respectively. Because all coefficients were above 0.7, the tool was considered reliable.

Ethical considerations

Oral consent was obtained from the pediatric nurses stating that they agreed to participate in this study. The researchers explained the objectives and benefits of the study. The collected data were made anonymous so that individuals could not be identified and remained confidential. Data were collected with permission of the head of the NICU.

Practical work:

The study was performed in three phases (preparatory phase, implementation phase, and evaluation phase).

Phase I: The preparatory phases:

A literature review of nosocomial infections in neonates was performed by searching libraries, midline databases, and internet networks.

Approval was obtained from the administrator of Qena University Hospital and from the head of the NICU to conduct this work.

Verbal consent was obtained from each nurse who participated in the study. The nature and purpose of the study were clarified through initial interviews conducted with each nurse. Preparation of the tool used for the evidence-based infection prevention and control guidelines (Soliman, 2009; WHO, 2016) and educational training guidelines about infection prevention and control guidelines in the NICU were included in a booklet.

A pilot study:

A pilot study was conducted on three nurses (10% of the total sample) to assess the feasibility and applicability of the study tool and to test its clarity, completeness, and time involvement. The results of the pilot study illustrated that no refinements or modifications were necessary, so the subjects were included in the actual sample.

Phase II: The implementation phase:

Data collection lasted from the beginning of May 2020 to the end of July 2020. Data were collected three days/week during two shifts; the first shift was from 8 am: 2 pm, and the second shift was from 2 pm: 8 pm. The nurses were divided into six groups according to their workload; and each group consisted of five nurses. Each group was trained for four hours per day.

The educational program for each group lasted a total 12 hours distributed in three equal sessions each session required approximately 4 hours of practical content.

The pre-test data were obtained through checklists (tool II) assessing the presence or absence of the ideal infection control measures (including hand washing, IV cannula insertion, the use of disinfection, gowns, gloves…etc.) assessment was done and check list of infection control measures by researchers.

At the initial interview, the researcher introduced herself to initiate the line of communication and explain the purpose of the study. At the end of the first session, the nurses were informed about the time of the next session.

Educational training practice materials about infection prevention and control guidelines in the NICU were included in a booklet and given to each participant.

Each of the program sessions were usually started by briefing about what had been discussed in the previous session(s) and the objective of the new session, using the simple Arabic language. Each session ended with a summary of its contents. Feedback from the nurses was elicited to ensure the maximal educational benefits. After implementing the infection prevention and control guidelines data were collected one month after the first session and compared with the baseline assessment using

Small group discussions and demonstrations were used to implement the infection prevention and control guidelines that were given to nurses who attended the sessions.

Phase III: The evaluation phase:

During this phase, an evaluation of the effect of the evidence-based infection control guidelines on the pediatric nurses' performance was conducted one month after applying the training practice guidelines by interviewing and observing each participant alone. Through reassessing and comparing of nurses; practice pre and post implementing using (tool II), this phase conducted in the NICU at Qena University Hospital.

Limitations/difficulties of the study

The workload of the nurses was an obstacle because the researcher had to wait for a long time to begin the sessions with the participants. Furthermore, some of the participants were tired when listening, could not concentration well, and needed continuous repetition, which required significant time and effort.

Statistical analysis of data

Data entry and data analysis were performed using SPSS version 22 (Statistical Package for Social Science). The data were presented as the number, percentage, mean, and standard deviation. Chi-square tests and Fisher's exact test were used to compare qualitative

variables. An independent sample t-test was used to compare quantitative variables between different groups. Paired samples t-tests were used to compare quantitative variables between the pre-test and post-test. P-values were considered statistically significant when $P < 0.05$.

Results:

The data in **table (1)** indicate that the studied nurses ranged in age from 19-34 years; most of them (87.8%) were aged > 20 years, with a mean age of 23.23 ± 4.10. years. All of them had secondary technical school nursing education. They had between six months and nine years of experience and more than half of them (53.3%) ≥ of 2 years. of work experience. Additionally, 23.3% of the nurses were married.

Table 1: Personal demographic data of the studied nurses

Variables	No. (30)	%
Age: (years)		
≤ 20	10	33.3
> 20	20	66.7
Mean ± SD (Range)	23.23 ± 4.10 (19.0-34.0)	
Educational level:		
Secondary school of nursing	30	100.0
Years of experience:		
< 2	14	46.7
≥ 2	16	53.3
Marital status:		
Single	23	76.7
Married	7	23.3
Have children: (N = 7)		
Yes	5	71.4
No	2	28.6

Table 2 shows that were significant increases in the mean scores of nurses' practices related to IV cannula insertion, the preparation of IV fluids, the preparation of a multi-dose vial/ampoule, the administration of IV medications with IV fluids, and umbilical catheter care, after one month of the program (6.10 ± 0.92; 17.80 ± 1.97; 8.57 ± 1.48; 14.03 ± 1.40; and 9.60 ± 0.56) respectively than mean scores before program initiation (3.20 ± 0.96; 9.00 ± 1.98; 5.43 ± 1.68; 7.27 ± 2.15; and 8.47 ± 1.14) respectively.

Table 2: Relationship between the mean ± SD score of nurses' practices in the pre-/post-test regarding bloodstream infection prevention and control guidelines in the NICU

Guidelines for infection prevention	Maximum score	Pre-test	Post-test	P-value
		Mean ± SD	Mean ± SD	
1-Steps of IV cannula insertion	9	3.20 ± 0.96	6.10 ± 0.92	<0.001*
2-Critical steps in preparing of IV fluids	20	9.00 ± 1.98	17.80 ± 1.97	<0.001*
3-Critical steps in preparing of a multi-dose vial/ampoule	11	5.43 ± 1.68	8.57 ± 1.48	<0.001*
4-Steps of administering of IV medications with IV fluids	15	7.27 ± 2.15	14.03 ± .40	<0.001*
5-Umbilical catheter care	12	8.47 ± 1.14	9.60 ± 0.56	0.017*
Total score	67	33.37 ± 7.91	56.10 ± 6.33	<0.001*

*Statistically significant differences

Table 3 shows that there were significant increase in the mean scores of nurses' practices related to items of skincare, eye care, breastfeeding, and artificial milk after one month of the program (completion 7.17 ± 1.51; 1.80 ± 0.48; 11.20 ± 1.10; and 5.57 ± 0.77 respectively than mean scores before program initiation (6.03 ± 1.27; 1.07 ± 0.83; 8.27 ± 1.39; and 4.27 ± 1.28) respectively.

Table 4 shows that there were significant increase in the mean scores for hand washing, using personal protective gloves, and using personal protective gowns after one month of the

program (completion 14.77 ± 0.63; 15.50 ± 0.63; and 2.30 ± 1.02 respectively than mean scores before program initiation (12.13 ± 2.45; 13.80 ± 1.97; and 1.00 ± 0.95) respectively.

Table 3: Relationship between the mean ± SD scores of nurses' practices in the pre-/post-test regarding evidence-based infection prevention and control guidelines for skin, eye, and feeding in the NICU

Guidelines for infection prevention	Maximum score	Pre-test	Post-test	P-value
		Mean ± SD	Mean ± SD	
6-Skin care	11	6.03 ± 1.27	7.17 ± 1.51	0.003*
7-Eye care	2	1.07 ± 0.83	1.80 ± 0.48	<0.001*
8-Breastfeeding	13	8.27 ± 1.39	11.20 ± 1.10	<0.001*
9-Artificial milk	6	4.27 ± 1.28	5.57 ± 0.77	0.014*
Total score	32	19.64 ± 4.77	25.74 ± 3.86	0.002*

*Statistically significant differences

Table 4: Relationships between the mean ± SD scores of nurses' practices in the pre-/post-test regarding evidence-based infection prevention and control guidelines for standard precautions in the NICU

Guidelines for infection prevention	Maximum score	Pre-test	Post-test	P-value
		Mean ± SD	Mean ± SD	
10-Hand washing	17	12.13 ± 2.45	14.77 ± 0.63	<0.001*
11-Using personal protection gloves	18	13.80 ± 1.97	15.50 ± 0.63	<0.001*
12-Using personal protection gowns	4	1.00 ± 0.95	2.30 ± 1.02	<0.001*
Total score	39	26.93 ± 5.37	32.57 ± 2.28	<0.001*

*Statistically significant differences

Table 5 shows that there was significant improvement in the mean score of evidence-based standard precautions for infection control performed by pediatric nurses in the NICU regarding items of sterile instruments and devices [Changing and disinfecting the incubator every week for each neonate, Changing and disinfecting the incubator every 5 days for each neonate (less than 1 kilogram), changing ventilator circuits every 3 - 4 days, discarding suction catheter immediately after use, Period of suction catheter use and suction catheter fluid used (sterile or previously boiled water)] after one month of the program (5.83 ± 0.83) compared with before the program (1.67 ± 0.76) p<0.001.

Table 5: Relationships between nurses' practices in the pre-/post-test regarding evidence-based infection prevention and control guidelines for sterile selected instruments and devices in the NICU

13- Sterile instruments and devices	Pre-test (n= 30)		Post-test (n= 30)		P-value
	No.	%	No.	%	
Disinfect incubator for each neonate:	30	100.0	30	100.0	1.000
Change and a disinfect incubator every week each neonate:	2	6.7	30	100.0	<0.001*
Change and a disinfect incubator every 5 days each neonate (less than 1 kilogram):	0	0.0	22	73.3	<0.001*
Ventilator circuits should be replaced every 3 - 4 days**:**	6	20.0	17	56.7	0.003*
Discard suction tubing immediately after use:	6	20.0	21	70.0	<0.001*
Replace suction tubing after 6 hours if continuously used**:**	4	13.3	30	100.0	<0.001*
sterile or previously boiled water should be used for suction or for ventilator humidifiers:	2	6.7	25	83.3	<0.001*
Mean ± SD	1.67 ± 0.76		5.83 ± 0.83		<0.001*

***Statistically significant differences**

Figure 1 shows that there was a significant improvement in mean scores of total nurses' performance regarding evidence-based infection prevention and control guidelines after one month of the program (119.20 ± 6.14) compared with before program (82.07 ± 8.95).

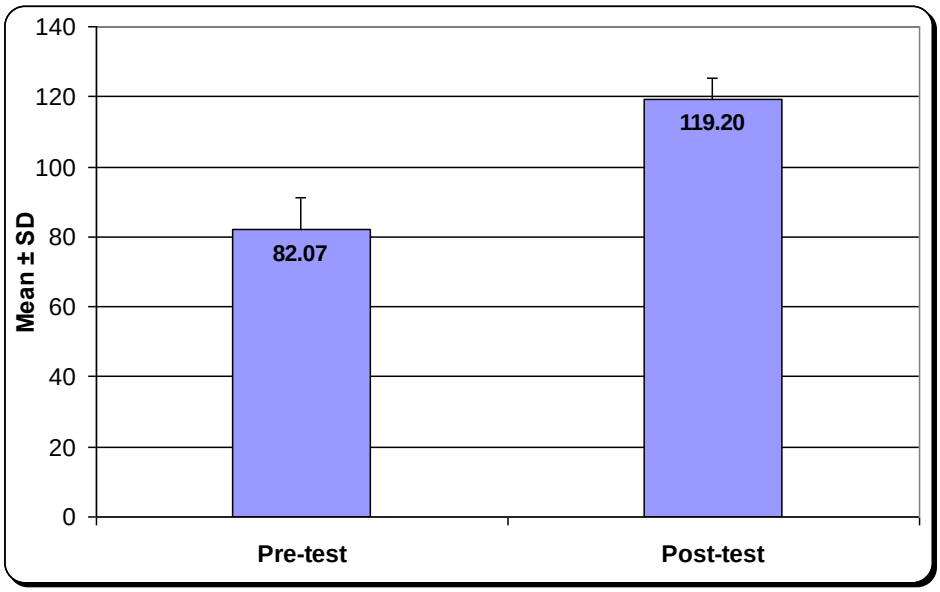

Figure (1): Relationship between mean ± SD score of total nurses' performance in the pre/post-test regarding evidence-based infection prevention and control guidelines in the NICU

Table 6 illustrates that there was a significant difference in the pediatric nurses' practices after implementing the program according to their years of experience. The pre-test results showed that nurses who had less than two years of experience had significantly better total mean scores in their practices (85.71 ± 8.77) compared with those who had ≥2 years of experience 78.88 ± 8.07) p > 0.034. Conversely, the post-test results showed that nurses who had less than two years of experience had significantly lower total mean scores in their practices (114.86 ± 5.79) compared with those who had ≥2 years of experience 123.00 ± 3.29) (p < 0.001)**.**

Table 6: Relationship between the mean ± SD total performance scores in the pre-/post-test and personal data of the studied nurses

Variables	Pre-test Performance score Mean ± SD	P-value	Post-test Performance score Mean ± SD	P-value
Age: (years)				
≤ 20	81.70 ± 6.82	0.877	117.80 ± 4.85	0.386
> 20	82.25 ± 10.01		119.90 ± 6.70	
Years of experience:				
< 2	85.71 ± 8.77	0.034*	114.86 ± 5.79	<0.001*
≥ 2	78.88 ± 8.07		123.00 ± 3.29	
Marital status:				
Single	81.78 ± 10.00	0.759	118.09 ± 6.45	0.071
Married	83.00 ± 4.43		122.86 ± 3.02	
Have children:				
Yes	81.40 ± 4.28	0.141	124.00 ± 2.83	0.117
No	87.00 ± 0.00		120.00 ± 0.00	

*Statistically significant differences

4. Discussion

Infection prevention and control practices can be improved by implementing evidence-based infection prevention and control guidelines (**Buchan et al., 2010)**. Because nurses are constantly in-touch with the patients and are an important link between the clinician and patient, the training program aims to create a large work force of empowered nurses who can help with the prevention and control of infection within the hospital, which has a huge potential to improve clinical outcomes **(WHO, 2015).** This study aimed

to evaluate the effect of evidence-based infection control guidelines on pediatric nurses' practices in the NICU.

The present study showed that there was significant improvement in the mean score of nurses' practices regarding evidence-based infection prevention and control for IV cannula insertion among pediatric nurses in the NICU after one month of the program compared with their mean score before the program ($p < 0.001$). These findings are in agreement with the findings of studies by **Freeman et al. (2015), Worth et al. (2018), Aloush & Alsaraieh (2018), and Jimenez et al. (2015)**, who noted that the implementation of central and peripheral line-associated bloodstream infection prevention protocols resulted in statistically significant reductions in infection.

The present study indicated that there was significant improvement in the mean score of nurses' practices regarding evidence-based infection prevention and control related to the preparation of IV fluids in the NICU after one month of the program (17.80 ± 1.97) compared with their mean score before the program ($p < 0.001$). These results are supported by the **National Centre for Disease Control (2020)**, which noted that the IV administration of fluids and drugs is a potent source of infection for vulnerable neonates. Strict attention to aseptic techniques is essential in the preparation and administration of IV fluids.

The study findings showed that there was a significant improvement in the mean score of nurses' practices regarding evidence-based infection prevention and control for the preparation of a multi-dose vial/ampoule among pediatric nurses in the NICU after one month of the program compared with their mean score before the program ($p< 0.001$). These findings are in agreement with the findings of **Susan et al., (2010)** study who noted that implementing the use of multi-dose vial/ampoule guidelines was able to reduce the incidence of bloodstream infections

Our study shows that there was significant improvement in the mean score of nurses' practices regarding evidence-based infection prevention and control for the administration of IV fluids with IV medications in the NICU after one month of the program compared with their mean score before the program ($p < 0.001$). These results are consistent with those obtained by **Xu et al. (2013) and Chernecky et al. (2014).**

The insertion or removal of the umbilical catheter was done by doctors only. The role of nurses assistance and informing doctors about problems in the catheter.

In the present study, there was a significant increase in the mean score of nurses' practices related to umbilical catheter care, including, standardized line changes, Use antiseptic on the umbilical insertion site, and daily assessment of catheter site for signs of infection and dressing after one month of the program compared with their mean score before the program. These findings are in agreement with the findings a study by **Payne et al., 2018, Pogorzelska-Maziarz, (2016), and Bannatyne et al., (2018)** who advised full sterile dressing changes only if the dressing's integrity was compromised; this recommendation was echoed throughout the literature **Cho and Cho, (2019), MacMullan and Gordon, (2016), and Mobley and Bizzarro, (2017).** Furthermore, these results are confirmed by the National Centre for Disease Control 2020, which advised that umbilical arterial catheters should be removed as soon as possible and not be left in place for more than five days. The catheter should be removed if there are signs of vascular insufficiency in the lower limbs. Umbilical venous catheters should be removed as soon as possible and left in place for no more than 14 days.

The present study revealed that there was a significant increase in the mean score of the nurses' practices for skin care of the neonatal (a bathing frequency of 2–3 times per week) after the program compared with their mean score before the program. These findings are in agreement with the findings of studies by **Yashwantrao et al., (2019),and Fernandes et al., (2011),** who emphasized the importance of infants bathing three times per week with a low alkaline soap. Furthermore, the present study shows that the use of adhesive tape was excessively in 26.7% of nurses in the pre-test which was decreased to 23.3% in the post-test. These findings are supported by **Marks (2014),** who stated when choosing adhesives the adhesive that causes the least trauma whilst still effectively securing medical devices should be used..

The present study shows that nearly half of the nurses cleaned newborn eyes with unsterile cotton in the pre-test this percentage was decreased to 3.3% in the post-test. These findings are confirmed by **WHO (2013)** guidelines, stating that it is important to wipe both of the newborn's eyes with sterile gauze square and discard the wet cloth. Additionally, the present study shows that half of the nurses' administrated eye prophylaxis to newborns in the pre-test and this percentage was increased to 83.3% in the post-test. These findings are in agreement with the findings of studies by **Canadian Pediatric Society (2015), and Matejcek, & Goldman, (2013)** who reported requiring the administration of eye prophylaxis to all newborns. **AAP (2012)** reported that approximately 50% of infants delivered vaginally from infected mothers will acquire an infection and. 25–50% will develop purulent conjunctivitis unless treated prophylactically at birth with antibiotic eye drops (tetracycline or erythromycin).

The current study shows that breast milk is given according to the doctor's orders requesting the family for bringing breast milk, expression of breast milk by mother, and storing it a bottle. There was no information about how breast milk was collected and stored (whether aseptic technique techniques are used). There was no specific room for mothers to breastfed their babies or to express breast milk. This study reported improvement in the mean score of nurses' practices regarding evidence-based infection prevention and control related to the promotion of breastfeeding for neonates in the NICU after one month of the program application compared with their mean score before the program (P<0.001). These findings are in agreement with the findings of **Nneka & Nzegwu (2017), and APIC (2016)** who reported that Breastfed infants are fed with their own mother's milk that has been expressed. Human milk is stored aseptically in clean plastic containers. Labeling of the mother's own milk is confirmed by the receiving bedside nurse and the infant's parent (or designee) when the milk is delivered to the NICU.

The present study showed that **approximately** two-thirds of nurses used antiseptic **when preparing formula** in the pretest this rate was decreased to 3.3% in the post-test. Utensils and containers used to prepare formula should be sterilized, by boiling water ready-to-feed dairy foods should be consumed within four hours of removing their cover, equipment and material used should be sterilized by boiling for 1 min, and artificial milk should be refrigerated for a maximum period of 24 hours. These findings are supported by the study of **Nneka & Nzegwu (2017)** who stated and reported the same findings.

The present study showed significant improvement in the mean score of nurses' practices related to evidence-based standard precautions for infection control performed by the pediatric nurses at the NICU regarding hand washing practices and personal protection (gloves & gowns) after one month of the program compared with their mean scores before the program. These findings are in agreement with the findings of **Nneka & Nzegwu, (2017), the Center for Disease Control and Prevention (2018), and WHO (2019)** which illustrated that standard precautions are implemented to prevent human to- human transmission of infection. In addition to hand hygiene, the use of personal protective equipment, such as a mask, gloves, and a gown, should be guided by risk assessment and the extent of contact anticipated with blood and body fluids or pathogens.

The present study revealed that there was a significant improvement in the mean score of nurses' practices related to evidence-based standard precautions for infection control performed by pediatric nurses in the NICU regarding hand washing practices after one month of the program compared with their mean score before the program ($p < 0.001$). This finding is supported by the studies of **Dhanorkar & Mathew (2016), Nneka & Nzegwu, (2017), and Sharma, et al., (2018)** who stated and reported the same finding.

The present study revealed that there was a significant improvement in the mean score of nurses' practices related to changing and disinfecting the incubator every week for each neonate, Changing and disinfecting incubator every 5 days for each neonate (less than 1 kilogram), after one month of the program compared with their mean score before the program. These findings are in agreement with the findings of **Fattorini et al., (2018)** who reported that disinfection procedures were performed by trained staff of the unit when the newborn was discharged / transferred or the length of stay of the newborn in the same incubator lasted more than seven days.

The present study showed that 80% of nurses did not replace **the ventilator circuits** after 3-4 days in the pre-test and this percentage was decreased to 0 %. This result is not consistent with the study by **Han, et al., (2010),** who reports that circuit changes every 2 or 3 days versus every 7 days, circuit changes at regular intervals versus no routine change risk of pneumonia with different circuit-change frequencies cost saving due to infrequent circuit change.

The present study showed that nurses usually use (sterile or previously boiled water) as the suction catheter fluid. Discard suction catheter immediately after use or replace suction tubing after 6 hours. These results are in agreement with those of **Elmansoury & Said (2017)** who reported that open suctioning systems use a new and sterile catheter each time whereas closed system catheters are reused several times within the 24-h period. One may speculate that contaminating bacteria from previous suction procedures would multiply on contaminated catheters of closed suctioning systems over time. Thus the suction catheter should be rinsed with sterile water decanted into a container (not directly from the bottle).

This study showed that the infection prevention and control practices of nurses can be improved by implementing evidence-based infection prevention and control guidelines. This result is consistent with those of **Soliman & Abdel-Raoof (2017), and Desta et al., (2018)** who reported that nurses' knowledge and performance were poor in the pre-program and improved in the post-program tests.

Haile et al., (2017), and Eskander et al., (2013) reported that this is due to the fact that those who adhere to the infection prevention guidelines know the up-to-date information and perceive that they are being exposed to healthcare-acquired infections (HAIs) which improves their practice. Furthermore, **Zhu et al.,(2019)** reported that knowledge and attitude alone do not guarantee practice and that more education is necessary for strategies to improve infection control.

Conclusion:

The infection prevention and control practices of pediatric nurses can be improved by the implementation of evidence-based infection prevention and control guidelines

Recommendations: Based on the findings of the present study the following is recommended:

- Regular training sessions and workshops on infection prevention and control guidelines. in NICUs should be organized by official institutions for nurses.
- The current study should be replicated in a larger probability sample in the same study setting and adopted in other similar settings with required modifications.
- Other studies should measure the effect of implementing evidence-based infection prevention and control guidelines on neonates in the NICU.

- A continuous educational and training program with the regular dissemination of updated infection prevention and control guidelines information is an essential component of educational programs that should be planned and offered on a regular basis for nurses.

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