

Effect of Preventive Bundle Guidelines on Nurses' Knowledge and Practice towards Healthcare-Associated Infections in NICU

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Abstract: Health care-associated infections (HAI) in the neonatal intensive care unit (NICU) lead to increase morbidity and mortality rates, long staying in NICU, and increase costs. Therefore the study aimed to evaluate the effect of preventive bundle guidelines application on nurses' knowledge and practice towards HAI in NICU. A quasi-experimental design was used in this study. *Setting:* the study was carried out in NICU affiliated to Mansoura University Children's Hospital (MUCHs), Egypt. *Subjects:* The subjects of this study was comprised of all nurses (53) working in NICU. *Tools:* data collection tools include a structured questionnaire sheet to assess nurses' knowledge about preventive bundle guidelines for HAI and observational checklist sheet regarding the practice of preventive bundle guidelines of HAI in NICU. *Results:* There was a statistically significant difference regarding nurses' knowledge and practice towards HAI in NICU immediately post and at follow up compared with before application of preventive bundle guidelines. *Conclusions:* it concluded that there was an improvement in the nurses' knowledge and practice after preventive bundle guidelines application for HAI prevention and control in the NICU. *Recommendations:* Continuing education interventions need to be conducted more frequently for nurses with continuous monitoring their feedback to encourage them to follow best practices to prevent and manage HAI in NICU.

Keywords: Preventive Bundle Guidelines, nurses, knowledge, practice, healthcare-associated infections (HAI), NICU.

1. INTRODUCTION

Today, healthcare-associated infections (HAI) is a global health problem and the greatest threat to patient safety in critical care units, which lead to increase mortality and morbidity, as well as an impact on patient's quality of life and community economic burden. Up to 7% of patients in developed and 10% in developing countries will have at least one type of HAI. Therefore HAI is a major challenge to the health-care system and its prevention and management take a top priority for patient safety in acute-care hospitals worldwide through applying the effective infection prevention and control (IPC) measures (CDC, 2010 ; Zingg et al, 2015; WHO, 2016 and 2018). Therefore inadequate environmental hygiene and low adherence to infection prevention and control measures are the leading causes of increased HAI rate (Ceballos, et al 2013; Wang, et al. 2019).

Neonatal Intensive Care Unit (NICU) is vulnerable to outbreaks and sporadic incidents HAI. In addition, premature infants are 20 times more risk for infection in resource-limited settings compared to developed country context. This is due to their immature immune systems, decrease protective endogenous flora on skin and mucosal surfaces at time of birth, impaired host-defense mechanisms, reduced barrier function of their skin and mucous membranes, low levels of immunoglobulin, expose to frequent invasive procedures and devices, broad-spectrum antibiotic agents and many different caregivers. Although this care is needed for babies to grow and thrive, but it also places them at risk for infection (Ramasethu, 2017; Haque et al. 2018). Therefore, core components for infection prevention and control are important to

decrease long staying in NICU, reduce devices used for monitoring and management, severity of the underlying illness and impairment of the newborns and their families quality of life (Verklan & Walden, 2010; Rimpi et al. 2015; Garland, 2010; Sengupta et al. 2010; Ward, 2011).

Continuous in-services educational training programs in NICU is very important to ensure from proper implementation of the infection prevention and control strategies. Which require integrated team effort from all staff, who participates in neonatal care. (Polin, Denson, and Brady, 2012; WHO, 2016; Sharma, Zaka and Hailegebriel, 2018). Nurses are high risk to expose daily to microorganisms during their direct contact with neonates. Therefore using evidence-based aseptic techniques, proper use of protective personal equipment (PPE) and proper hand hygiene by the nurses are important to reduce the risk for HAI Liz, 2012; Galal, 2014; Saleh, 2017).

It is necessary to organize infection control training sessions and ensuring adequate supplies and resources to apply core components measures of HAI prevention properly (Vaishnav, 2016). Regular training of nurses using bundled interventions important to improve the nurses' compliance with infection control standard precautions. Using competency checklists to train the nurses about HAI prevention, hold them accountable and they feel empowered and engaged in patient safety and quality of care (Marschall, 2014; El- Greeb, et al, 2018).

Bundles of care application in health care settings is essential to build consistent care systems for ensuring evidence-based interventions are delivered and to improve quality of care in pediatric and neonatal units, so it used to reduce certain HAI prevention. Proper application of HAI prevention bundle of care requires that the core measures are adapted to the local setting; monitoring system; documentation and evaluation to ensure adherence from all staff (Lavallée et al. 2017; Wasserman et al., 2018; WHO, 2018). Neonatal nurses are pillars of the NICU. So their knowledge and practice are essential in providing best practices in quality care in preventing HAI (Murki and Kadam, 2018). However, there are few studies about the incidence of HAIs in premature infants. As well, studies that evaluate nurses' knowledge and practice regarding infection control standards in NICUs are scarce and recommended. Therefore this study aimed to improve nurse's knowledge and practice after application of preventive bundle guidelines regarding HAI in NICU.

Significant of the study:

Healthcare-associated infection (HAI) in the NICU lead to raise morbidity and mortality rate, long stay in NICU and financial burden in the community (Haque et al., 2018). So Healthcare Infection Control Practices Advisory Committee (HICPAC), 2017 recommendations different core practice categories are considered standards of care and accepted practices to providing safe and high-quality patient care across all settings where healthcare is delivered. Nurses play an important role in prevention and control of HAI in NICU. So, they are the key members of infection control team in hospitals (Asadollahi et al., 2015). Preventive bundles guidelines used to equip the nurses with proper knowledge and skills in the field of infection control. Effective application of bundles of care for ensuring that evidence-based practice delivered and improve quality and safety of NICU care when applied correctly. Further research is recommended to enhance the elements of the bundles and to evaluate new applications for them (Lachman and Yuen 2009). Therefore implementing core infection prevention and control strategies to prevent HAI in NICU include: hand hygiene, Standard Precautions, environmental cleaning, healthcare personnel education and training, and reinforcing implementation of and monitoring adherence to these strategies as outlined in Core Infection Prevention and Control Practices (HICPAC, 2017; Bryant, 2018).

2. METHODOLOGY

Aim of the study:

The aim of this study was to evaluate the effect of preventive bundle guidelines application on nurses' knowledge and practice towards HAI in NICU.

- Assess nurses' knowledge and practice about preventive bundle guidelines towards HAI in NICU.
- Designing and implementing preventive bundle guidelines towards HAI in NICU on nurses' knowledge and practice.
- Evaluating the effect of implementing preventive bundle guidelines on nurses' knowledge and performance about HAI in NICU.

Operational definitions:

- **Bundle:** An implementation tool aiming to improve the care process and patients' outcomes in a structured manner. It comprises a small, straightforward set of evidence-based practices (generally 3 to 5) that have been proven to improve patients' outcomes when performed collectively and reliably (WHO, 2016).
- **Health care-associated infection (HAI)** (also referred to as "nosocomial" or "hospital infection"): An infection occurring in a patient during the process of care in a hospital or other health care facility, which was not present or incubating at the time of admission. HAI can also appear after discharge. They represent the most frequent adverse event associated with patient care (WHO, 2016).
- **Neonatal Intensive Care Unit:** A unit of a hospital specialized in the care of critically ill and / or premature newborn infants

Research Hypothesis:

Nurses who participate in the preventive bundle guidelines application expected to have good knowledge and competent practice about prevention and control of HAI in NICU.

Research Design:

A quasi-experimental design was used for this study.

Setting:

This study was carried out in NICU affiliated to Mansoura University Children's Hospital (MUCHs), Mansoura city, Egypt.

Subjects:

The subjects was convenience sample comprised of all nurses (53) working and providing direct nursing care for neonate in NICU regardless of their age, qualification or years of experience

Tools of Data Collection:

Two tools were used to collect the data namely: a structured questionnaire sheet and observational checklist sheet, which were developed by the authors after reviewing related recent literature (The National Health and Medical Research Council, 2010); McGeer, et al., 2015; Wasserman, et al, 2018).

Tool I: Nurses' Knowledge about Preventive Bundle Guidelines for HAI: It includes questions in the form of multiple choice questions to assess nurses' knowledge regarding the prevention of HAI in NICU. Which classified to 6 main items included nurses' knowledge about sterilization, disinfection, cycle of infection, risk factors for neonatal infections, care-related risk factors that increase the risk of infection, contributing factors for HAI, core measures of prevention of HAI in NICU and its importance.

Tool II: Observational checklist sheet: It was used to evaluate the actual nurses' practice regarding the preventive bundle guidelines application of HAI in NICU during daily care with neonate. Preventive bundle guidelines was developed by the researchers after reviewing the literature, related research studies (Polin, Denson & Brady, 2012; Balas et al. 2012; Ceballos et al. 2013) and based on the EBPs guidelines of Centers for Disease Control and Prevention (CDC, 2011), which was the benchmark for all care recommendations and provided guidelines for best practices as regards the prevention and monitoring of HAI in NICU before, during, and after bundle of care. The checklist was used to assess and evaluate the nurses' practice related to preventive bundle guidelines for HAI. It covers 6 main items with 90 sub-items related to the appropriate hand hygiene and using of personal protective equipment, the prevention of central line-associated bloodstream infections, the prevention of ventilator-associated pneumonia, the prevention of infection related to nutrition (early enteral feeding, reduce duration of total parenteral nutrition, cleaning and disinfecting feeding equipment, expressed breast milk, fortifiers and additives, powdered infant formula), the appropriateness of antibiotic use (judicious use of antimicrobials for therapy and prophylaxis and prevention of misuse), incubators care, daily routine care and patient placement (isolation).

Scoring System

The scoring of the nurses' answers structured questionnaire sheet to assess their level of knowledge was poor if the percent score was ($< 60\%$), average if the percent score was ($60\% - < 75\%$) and good if the percent score was ($\geq 75\%$). As regards to their practice core components of infection control in NICU was competent if the percent score was ($\geq 85\%$) and incompetent if ($< 85\%$).

3. DATA COLLECTION

Ethical considerations:

An ethical approval was attained from the Faculty of Nursing Research Ethical Committee, Mansoura University. Then, oral informed consents were obtained from the nurses after complete description of the study aim and process by the authors to obtain their acceptance for participation. Nurses were informed that their participation in the study is voluntary; they have the right to withdraw from the study at any time without giving any reason. Confidentiality of the information collected and anonymity were assured for the nurses.

Validity and Reliability:

The tools were revised by seven experts in the pediatric nursing and neonatal medicine fields to test its content validity. The modifications were done on the tools according to their opinions. The reliability of both tools was test using Alpha Cronbach's coefficient test, the alpha reliability of tool I was ($\alpha = 0.90$) and tool II was ($\alpha = 0.93$).

Pilot study:

It was carried out on 10% of nurses (5) in order to assess the tools' clarity and applicability and the modifications were done accordingly.

Data collection:

- Data collected process was started from November 2015 to May 2016 to conduct this study within seven months. Permission attained from Faculty Nursing Dean and director of previously mentioned hospital before collection of data. Then, the researchers communicated with head nurse of NICU to explain the study aim and nature. The head nurse introduced the researchers to the nurses, and they inviting all nurses for voluntary participation in the current study.

Intervention:

Assessment phase:

- Educational sessions with nurses carried out at NICU.
- The researchers introduced themselves and explain the study aim and process, the nurses' roles during their participation. Then every nurse was subjected to the following:
 - Determine their knowledge about core components of HAI. The times allowed for nurses was 15-20 minutes to fill the questionnaire, the time for each session ranged from 20 -30 minutes in the morning and afternoon shift depending up on their available time.
- As regards nurses' practice, the researchers observed the nurses during daily and routine care of neonates at NICU using observational checklist for the core components of HAI.

Implementation phase:

- The authors designed the preventive bundle guidelines about HAI in NICU based upon the nurse's needs assessment to achieve the study objectives.
- The contents of the preventive bundle guidelines were given over 8 sessions, divided to three theoretical sessions and five practical.
- According to the morning and afternoon shifts' work schedule of the study nurses, the researchers divided the nurses into small groups for discussion. Each group having 5 nurses.

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- The researchers demonstrated all clinical aspects of preventive bundle guidelines for HAI and give brief conclusion at the end of each session for the nurses.
- Nurses' practice was evaluated immediately after application and three months later using Tool II.
- The checklist was used to evaluate the nurses' practice related to preventive bundle guidelines for HAI. This checklist was used to observe the actual nurses' practice during daily care with neonate. The observation of nurses' practice was carried out during morning and afternoon shifts.
- Different teaching methods were used during the application of preventive bundle guidelines such as: brainstorming, group discussion, demonstration and re-demonstration, poster, video film, as well as booklet were used as teaching media.

Evaluation phase:

The preventive bundle guidelines were evaluated immediately and three months after the application using (Tool I and Tool II).

Statistical Analysis:

Statistical Package for the Social Sciences (SPSS) for version 19.0 was used for data analysis. The data were presented using descriptive statistics in the form of frequencies and percentage, means and standard deviations for quantitative variables. The following statistical measures were used: Chi square and Wilcoxon Signed Ranks tests were used for test of significance. The results were accepted to be statistically significant for $p < 0.05$. The results were accepted to be statistically significant for $p < 0.05$.

4. RESULTS

Table (1); Distribution of Studied Subjects according to their demographic characteristics (N= 53)

Items	Frequency	%
Age in years		
▪ 20 - < 25 yrs.	14	26.4
▪ 25 - < 30 yrs.	11	20.8
▪ 30 - < 35 yrs.	19	35.8
▪ 35 + Y	9	17.0
$X^2 \pm SD$	29.9 ± 3.4	
Level of education:		
▪ Bachelor degree in nursing science	31	58.5
▪ Technical nursing institute	3	5.7
▪ Nursing Diploma	19	35.8
Years of experience in the NICU:		
▪ < 1 yrs.	7	13.2
▪ 1 - < 5 yrs.	10	18.9
▪ 5 - < 10 yrs.	16	30.2
▪ 10 + yrs.	20	37.7
$X^2 \pm SD$	8.5 ± 2.1	
Participation in any training courses toward preventive bundle guidelines of HAI:		
▪ Yes	21	39.6
▪ No	32	60.4

Table (1) revealed that, 35.8% of the nurses were aged from 30 to less than 35 years with mean age of 29.9 ± 3.4 . More than half of the studied nurses (58.5%) had a bachelor degree, while 35.8% had a diploma in nursing. As regards nurses' years of experience, it was noticed that more than one third of (37.7%) having more than 10 years' experience in NICU with the mean years of experience 8.5 ± 2.1 years. In addition, the majority (60.4%) of nurses did not have training courses toward preventive bundle guidelines of HAI.

Table (2); Nurses' Knowledge towards Healthcare-Associated Infections in NICU pre, immediate post and at follow up after application of Preventive Bundle Guidelines (N= 53)

Items	pre		Immediate post		Follow up		P- value
	No	%	No	%	No	%	
1. Knowledge about sterilization							
Poor	23	43.4	11	20.8	18	34.0	<0.001**
Average	19	35.8	8	15.1	6	11.3	
Good	11	20.8	34	64.1	29	54.7	
2. Knowledge about disinfection							
Poor	33	62.3	13	24.5	15	28.3	<0.001**
Average	14	26.4	8	15.1	8	15.1	
Good	6	11.3	32	60.4	30	56.6	
3. Cycle of infection							
Poor	31	58.5	14	26.4	16	30.2	<0.001**
Average	12	22.6	7	13.2	7	13.2	
Good	10	18.9	32	60.4	30	56.6	
4. Risk factors of neonatal infections							
Poor	33	62.3	13	24.5	15	28.3	<0.001**
Average	14	26.4	8	15.1	8	15.1	
Good	6	11.3	32	60.4	30	56.6	
5. Care-related risk factors that increase the risk of infection							
Poor	32	60.4	9	17.0	8	15.1	<0.001**
Average	15	28.3	10	18.9	13	24.5	
Good	6	11.3	34	64.1	32	60.4	
6. Contributing Factors of Healthcare Associated Infections							
Poor	23	43.4	11	20.8	18	34.0	<0.001**
Average	19	35.8	8	15.1	6	11.3	
Good	11	20.8	34	64.1	29	54.7	
7. Core measures of prevention of healthcare-associated infections in NICU							
Poor	26	49.0	3	5.7	4	7.5	<0.001**
Average	16	30.2	7	13.2	8	15.1	
Good	11	20.8	43	81.1	41	77.4	
8. Importance of measures of prevention of healthcare-associated infections in NICU							
Poor	32	60.4	9	17.0	8	15.1	<0.001**
Average	15	28.3	10	18.9	13	24.5	
Good	6	11.3	34	64.1	32	60.4	

Table (2), this table demonstrated that there were highly statistically significant differences regarding nurses' knowledge towards HAI in NICU pre, immediate post and at follow up after application of preventive bundle guidelines.

Table (3); Nurses' Practice regarding Core Measures of Prevention of Healthcare-Associated Infections in NICU pre, immediate post and follow up after application of Preventive Bundle Guidelines

Items of Preventive Bundle Guidelines	Pre				Immediate post				Follow up				P value
	Competent		Incompetent		Competent		Incompetent		Competent		Incompetent		
	No	%	No	%	No	%	No	%	No	%	No	%	
▪ The appropriate hand hygiene and using of personal protective equipment	31	58.5	22	41.5	47	88.7	6	11.3	44	83.0	9	17.0	0.02*
▪ The prevention of central line-associated bloodstream infections	12	22.6	41	77.4	38	71.7	15	28.3	38	71.7	15	28.3	<0.001**
▪ The prevention of ventilator associated pneumonia	8	15.1	45	84.9	36	67.9	17	32.1	37	69.8	16	30.2	<0.001**
▪ The appropriateness of antibiotic use (judicious use of antimicrobials for therapy and prophylaxis and prevention of misuse)	7	13.2	46	86.8	34	64.2	19	35.8	32	60.4	21	39.6	<0.001**
▪ The prevention of infection related to nutrition (early enteral feeding, reduce duration of total parenteral nutrition, cleaning and disinfecting feeding equipment, expressed breast milk, fortifiers and additives, powdered infant formula).	15	28.3	38	71.7	39	73.6	14	26.4	36	67.9	17	32.1	<0.001**
▪ Incubators care, daily routine care and patient placement (isolation)	18	34.0	35	66.0	36	67.9	17	32.1	34	64.2	19	35.8	<0.001**

Table (3), revealed that there were highly statistically significant differences in nurses' practice of core measures of prevention of healthcare-associated infections in NICU pre, immediate post and at follow up after application of preventive bundle guidelines. This means improvement in their practice level regarding all core measures items of HAI prevention in NICU immediately post and three month follow up the application of bundle of care compared with their level pre the application ($P \leq 0.001$).

Table (4); Nurses' total scores about knowledge and practice of core measures of prevention of HAI in NICU pre, immediate post and at follow up after application of preventive bundle guidelines (N= 53)

Items	Pre		Immediate post		Follow up		Wilcoxon Signed Ranks Test		
	No	%	No	%	No	%	Z1 & P1	Z2 & P2	Z3 & P3
Total Knowledge Scores									
▪ Poor	29	54.7	10	18.9	12	22.6	- 6.88(a) 0.000**	- 6.441(a) 0.000**	-2.038 (b) 0.042*
▪ Average	15	28.3	8	15.1	9	17.0			
▪ Good	9	17.0	35	66.0	32	60.4			
Total Practice Scores									
▪ Competent	15	28.3	39	73.6	36	67.9	- 6.708(a) 0.000**	-5.292(a) 0.000**	- 0.475 (b) 0.635
▪ Incompetent	38	71.7	14	26.4	17	32.1			

(*) Statistically significant at $P > 0.05$

Z1: Between Pre and immediate post

Z2: Between Pre and follow up

Z3: Between Immediate post and follow up

(a) Based on negative ranks.

(b) Based on positive ranks.

This table(4), showed nurses distribution according to their the total nurses' knowledge, it was noticed that 17.0% of nurses have good knowledge level pre application of preventive bundle guidelines, meanwhile, in post, more than of sixty-five (66.0%) and after three month follow up (60.4%) of nurses have a good knowledge level. Also, there is a highly statistical significant difference between nurses' total knowledge level pre and immediate post, and immediate post and at follow up as evidenced by ($P = 0.000$). Concerning nurses' practice regarding core measures of infection control in NICU, showed that the majority of nurses (71.7%) had incompetent practice before applying preventive bundle guidelines, while the nurses' practice was competent (73.6%, 67.1%) immediate post and at follow up respectively with highly statistical significant difference as evidenced by ($P= 0.000$).

Table (5): Relationship between characteristics of nurses and their total practice score pre, immediate post and at follow up after application of Preventive Bundle Guidelines

Items	Pre				Immediate post				Follow up				Test of significance		
	Competent		Incompetent		Competent		Incompetent		Competent		Incompetent		χ^2 & P ₁	χ^2 & P ₂	χ^2 & P ₃
	No	%	No	%	No	%	No	%	No	%	No	%			
Age in years															
▪ 20 - < 25 yrs.	5	9.4	9	17.0	8	15.1	6	11.3	7	13.2	7	13.2	12.64 0.03*	10.51 0.05*	6.74 0.71
▪ 25 - < 30 yrs.	3	5.6	8	15.1	7	13.2	4	7.5	6	11.3	5	9.4			
▪ 30 - < 35 yrs.	7	13.2	12	22.6	13	24.5	6	11.3	13	24.5	6	11.3			
▪ 35 + yrs.	4	7.5	5	9.4	4	7.5	5	9.4	5	9.4	4	7.5			
Level of education:															
▪ Bachelor degree in nursing science	11	20.8	20	37.7	26	49.1	5	9.4	27	50.9	4	7.4	16.64 0.01*	13.51 0.02*	4.74 0.51
▪ Technical nursing institute	1	1.9	2	3.8	3	5.6	0	0.0	2	3.8	1	1.9			
▪ Nursing Diploma	7	13.2	12	22.6	15	28.3	4	7.5	13	24.5	6	11.3			
Years of experience in NICU:															
▪ < 1 yrs.	2	3.8	5	9.4	7	13.2	0	0.0	6	11.3	1	1.9	11.64 0.04*	10.82 0.05*	4.74 0.51
▪ 1 - < 5 yrs.	4	7.5	6	11.3	8	15.1	2	3.8	8	15.1	2	3.8			
▪ 5 - < 10 yrs.	4	7.5	12	22.6	13	24.5	3	5.6	12	22.6	4	7.5			
▪ 10 + yrs.	7	13.2	13	24.5	18	34.0	2	3.8	16	30.2	4	7.5			

(*) Statistically significant at $P > 0.05$

P2: Between Pre and follow up

P1: Between Pre and immediate post

P3: Between Immediate post and follow up

Tables (5) illustrated the relation between characteristics of studied subjects and their total practice score pre, immediate post and at follow up after application of preventive bundle guidelines. It is evident that there is statistically significant relation between nurses' age (P. 0.03, P. 0.05), level of education (P. 0.01, P. 0.02), years of experience in NICU: (P. 0.04, P. 0.05) and their practice.

5. DISCUSSION

Healthcare-associated infection (HAI) is a public health problem all over the world. It is the main cause of morbidity and mortality among neonates. Consequently, up to-date knowledge's and practices of neonatal nurses play a vital roles in HAI control and prevention in NICU. Nurses practice the infection control core components is considered an integral part of daily neonatal care. Therefore the current study was carried out. This study findings demonstrated significant improvements in nurses' knowledge and practice regarding the preventive bundle guidelines application in NICU. The findings confirm the effectiveness of the preventive bundle guidelines application to control HAI in NICU.

As regarding nurses' characteristics, the finding of the present study revealed that slightly more than one third of nurses aged 30 to less than 35 years with mean age 29.9 ± 3.4 years, the majority of them had a bachelor degree, more than one third of them having more than 10 years' experience in NICU (Table 1). This was in disagreement with **Shauq et al. (2014)** who found that one third of participants were within 30-39 years-old age, the minority of them had college in nursing, more than half had < 5 years of experience in NICU and majority of them did not participate in training courses about universal precautions in NICU. The findings of this study presented that nurses' majority did not attend previous training courses toward preventive bundle guidelines of HAI. This in agreement with **El-Maghawry and El-Hawy (2019)** their results showed that more than one third of the studied nurses did not receive training program about infection control (34.2%). In addition to **Abolwafa et al. (2013)** who reported about 10% of the nurses had previous training courses attendance about infection control. This may be due to lack of nurses interest or lack of continues educational courses conducted through the infection control team in the hospital. This justify is appreciated by **Talaat et al. (2006)** who stated conducting infection control training programs in Egypt faced with restrictions that are common in developing countries, such as the lack of trained health care professionals and experts who can implement programs.

It is cleared from this study results that nurses' knowledge was significantly improved after participation in preventive bundle guidelines application (Table 2). This is similar to the previous study conducted by **Mohammed & Ibrahim (2016)** who found improvement of nurses' knowledge regarding infection control in NICU after implementation of health educational program. Also, this was in line with the study carried out in India by **Koshy & Patel (2015)** who compared between the post-test and pretest nurses' knowledge total scores about the infection control measures and they found to be highly significant.

The prevention of HAIs is a first priority in critical-care settings for patient safety worldwide (**Wang et al. 2019**). The findings of the current study illustrated that there were highly statistically significant differences in nurses' practice of core measures of prevention of HAI in NICU pre, immediate post and at follow up after application of preventive bundle guidelines. This means improvement in their practice level regarding all items of core measures of prevention of HAI in NICU immediately post and three month follow up the application of bundle of care compared with their level pre the application (table 3). These findings supported with **Balas, et al, (2012)** who stated that care bundle is a group of evidence-based interventions, guideline and protocol-based care which when delivered together lead to a better outcome than performing interventions individually. Moreover, these results in the same line with **Mohammed & Ibrahim (2016)** and **EL-Shafey, El-Dakhakhny & Mohammed (2019)** who demonstrated significant statistical improvement in practical skills after the educational program were offered to the nursing staff. And they recommended, in-service, training program for nurses about infection control precautions is required. In addition, the development of infection control guidelines is essential, to be followed and available for all nurses.

The findings of this study revealed that there is highly statistical significant difference in total scores of knowledge and practice of core measures of prevention of HAI in NICU pre, immediate post and at follow up after application of preventive bundle guidelines (table 4). These results were inconsistent with **Gijare, (2012)** stated there is no significant statistically difference in pre and posttest nurses' knowledge and practice total scores.

Concerning the relationship between characteristics of studied subjects and their practice total practice score pre, immediate post and at follow up after application of preventive bundle guidelines, the results found that there is statistically significant relation between nurses' age, education level, years of experience in NICU and their practice (Tables 5). This may be due to that most of the studied nurses were bachelor degree. These findings are inconsistent with **Sadawy, (2013)** who found that more than half nurses had nursing diploma and there is no significant relationship between nurses' practice and their educational qualification. Also, these results are in contrast with **Gijare, (2012)** reported no significant statistical difference in pre and posttest knowledge and practice scores of various age groups and different years of experience. In addition, **EL-Shafey, El-Dakhakhny & Mohammed (2019)** about who found that there was no statistical significant difference between nurses practice about infection control and neither their age nor their years of experience.

6. CONCLUSIONS

From current results of this study, it concluded that there was an improvement in the nurses' knowledge and practice after application of preventive bundle guidelines for prevention of HAI in the NICU.

7. RECOMMENDATIONS

- Continuous educational interventions and monitoring for nurses feedback about following best practices to prevent HAI in NICU.
- Duplicate the study with larger sample and multiple settings.
- Continuous evaluation from the hospital authorities to all nurses to ensure their competent in clinical practice.
- Continuous educational programs for the nurses and all the medical personnel about the prevention of HAIs according to world standards.
- Preventive bundle guidelines application should be adopted as an essential component of the continuing educational and training program for all the nurses and all healthcare providers working in NICU.

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