Intervention Program on Nurse's Performance Regarding Bundle Care Strategies to Prevent Ventilator-Associated Pneumonia Among Newborns

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Abstract

Background: Ventilator-associated pneumonia is a serious healthcare-associated infection that causes significant morbidity and increases the mortality rate among neonates. Furthermore, it extends hospitalization stays in addition to escalating healthcare costs. **Study Aim:** To evaluate the Impact of intervention programs on nurses' performance regarding care bundle strategies to prevent ventilator-associated pneumonia among newborns in the neonatal intensive care unit NICU. **Subjects and methods: Research design and setting:** A quasi-experimental study was conducted at Hurghada General Hospital in Red Sea Governorate to achieve the aim of the current study. **Subject:** 55 nurses who were providing direct nursing care to 89 neonates in the mentioned settings. **Tools for data collection:** Three tools were employed in the current study; The first tool includes sociodemographic data of the subjects (nurses & neonates) and a questionnaire for nurses' knowledge about bundle care and ventilated associated pneumonia in NICU, the second tool utilized was an observational checklist designed to assess the nurse's practices, and to avoid ventilator-associated pneumonia among neonates in NICU, and the last one was a neonatal assessment tool. **Results:** 43.6% of the nurses had satisfactory knowledge about VAP bundle care before the program implementation and this percentage increased to 78.2% after the implementation of the program. On the other hand, 47.3 % had poor performance before the program implementation, compared to 20.0% of them after the program implementation. Conclusion: there was a statistically significant positive association between nurses' knowledge and practices in implementing bundle care for neonates under ventilation before and after the program's implementation with ($p=0.001$ & 0.012 respectively). **Recommendations:** Regular auditing for nurses during practice to achieve the highest performance quality, as the nurses' knowledge improved better than their practices. Orientation of newly hired nurses in the NICU should include the VAP preventive care bundle. Every neonatal intensive care unit should include manuals, information pamphlets, and self-instruction modules about VAP preventative care packages.

Keywords: nurse`s performance, bundle care strategies, ventilator-associated pneumonia, newborns.

Introduction

Ventilator-associated pneumonia (VAP) is the second most prevalent healthcare-associated infection in the neonatal intensive care unit (NICU). As a result, updating knowledge about the incidence of newborn VAP, as well as potential preventative methods, is critical. VAP incidence varies between 1.4 and 7 episodes per 1000 ventilator days in wealthy nations and 16.1 to 89 events per 1000 ventilator days in developing countries (**Ergenekon & Çataltepe 2020, Raycheva et al., 2022, and Rangelova et al., 2024**).

Ventilator-associated pneumonia (VAP), a hospital-acquired pneumonia that occurs more than 48 hours after mechanical ventilation, is a common problem of mechanical ventilation with a higher communal infectious disorder in critical care units with an increasing mortality rate (**Mohamed et al., 2023**). The gastric fluid pool, tracheal secretions, and colonized naso/oropharynx are the routes by which endogenous microorganisms enter the lung, so aspirating contaminated fluids into the lungs is the usual cause of ventilator-associated pneumonia (VAP). Furthermore, bacteria can enter the lungs from external sources such as caregiver hands, ventilator circuits, and biofilms on endotracheal tubes (ETTs) (**Osman et al., 2020 & González et al., 2021)**. This subtype of

pneumonia is the most serious one, affecting newborns who are artificially ventilated and resulting in significant morbidity, a twofold increase in mortality, and additional expenses. These factors are often combined with prolonged ventilator use and prolonged hospital stays in neonatal intensive care units (NICU) (**Khalil et al., 2021 & Rangelova et al., 2022).**

Preventive bundles have been established by several NICUs to reduce Ventilator-associated pneumonia. These bundles include keeping the intubated neonate's environment as clean as possible (hand hygiene, sterile equipment handling), putting the neonate to prevent reflux, and routinely re-examining the neonate's readiness for extubating (**Darawad et al., 2018, Greenberg, 2020, & Kazem et al., 2024).**

Bedir et al., 2021 & Katoch et al., 2021 mentioned that due to poor host factors, serious underlying illnesses, extended use of ventilatory support, and frequent use of intrusive devices and procedures, neonates in the NICU on mechanical ventilation have a greater likelihood of developing Ventilator-associated pneumonia. Nursing personnel should thoroughly understand the potential negative consequences of mechanical ventilation to reduce risk, prevent issues, and offer prompt assistance when needed.

The "bundle approach" has been the main strategy used to prevent VAP among neonates. This entails applying many preventative measures at the same time to every neonate, frequently with the use of checklists and other tools. Although the effectiveness of one or more bundle pieces may only be supported by theoretical proof or biological plausibility in certain instances, the utilization of these bundles has been increasingly popular and successful in recent years. A bundle strategy and the implementation of an educational program for the nurses in NICU can prevent ventilator-associated pneumonia (VAP), which statistically reduces the condition's recurrence density. (**Dipanjali et al., 2020 & Abiramalatha et al., 2021)**

The significance of the study:

Ventilator-associated pneumonia (VAP) is the second leading cause of morbidity and mortality among patients on mechanical ventilation. Around the world, there are one to sixty-three VAP occurrences for every 1000 ventilator days in neonatal intensive care units (NICUs), indicating not only the burden of the disease but also the variability in screening practices (**Rangelova et al., 2020, Amin et al., 2021, & CDC, 2021**). Because of their small gestational age and undeveloped lungs, preterm neonates require artificial ventilation, which increases the requirement for respiratory support. Moreover, between 60 and 95 percent of premature babies born worldwide need mechanical ventilation after delivery. Nurses provide 24-hour care for ventilated neonates in the NICU. As a result, good knowledge and performance of VAP preventive strategies can contribute to a reduction in VAP load in the neonatal critical care unit (**de Mello et al., 2021 & Alriyami et al., 2022)**. In Egypt, Infections such as pneumonia, meningitis, sepsis/septicemia, and other infections account for 28% of deaths during the neonatal period **(Abdel Rahman et al., 2021).** From this point of view, the current study was conducted to investigate potential disparities in the knowledge and practical implementation of VAP prevention measures among staff nurses caring for newborns following the implementation of an educational intervention.

Aim of the study:

To evaluate the Impact of intervention programs on nurses' performance regarding care bundle strategies to prevent ventilator-associated pneumonia among newborns at NICU.

Research Hypothesis: The implementation of an educational program about nurses' performance regarding care bundle strategies will prevent VAP among newborns in the NICU.

Subjects and methods:

Research design: A quasi-experimental study design will be conducted to achieve the aim of the current study.

Subjects & setting: Convenience sampling type was used in this study, as all nurses (**55**) in the neonatal intensive care unit, all ventilated neonates (**89**) during the study time, who were ventilated for more than 48 hours at Hurghada General Hospital as this is the only governmental hospital in Red Sea Governorate that includes 25 incubator

and the data were collected from October 2023 to January 2024 as the nurse to neonate ratio is 1 to 1/ 2.

Inclusion criteria: all nurses working in the NICU and providing care for neonates undergoing artificial ventilation, all neonates were admitted to the NICU with respiratory disorders / or health problems that need artificial ventilation for more than 48 hrs.

Data collection tools: three tools were used in the current study.

Tool I; includes sociodemographic data of the subjects (nurses & neonates) and a questionnaire for nurses' knowledge about bundle care and ventilated associated pneumonia in NICU; definition, risk factors, signs & symptoms of VAP and questions about the appropriate nursing intervention to prevent VAP.

Tool II; is an observational checklist to evaluate the nurses' practices to avoid ventilator-associated pneumonia among neonates in NICU, it was adopted by (**Gokce, et al., 2018, Greenberg, 2020 & CDC, 2021),** and it is used to evaluate the nurses' performance related to (infection control maneuvers, neonatal positioning, ventilator care, endotracheal tube (ETT) suctioning, oral care; swabbing, moist lips, gastric ulcer prophylaxis, extubating and a number of ETT weaning trials).

Tool III: neonatal assessment tool; duration of mechanical ventilation (MV), length of NICU stay, antibiotics used, other culture-positive infections while on MV, and C-Reactive Protein (CRP) was recorded for each neonate.

Scoring system:

A total of 24 multiple-choice questions with one right answer are included in the structured knowledge tool. One mark is awarded for each right response, and zero for an the incorrect one. The nurses` knowledge score was categorized as "Satisfactory", and "Unsatisfactory", as the scores were converted to percentages, and it was 75% or less considered unsatisfactory, and more than 75% was satisfactory knowledge. For practices, there were 29 items categorized into three levels; competent, fair, and incompetent practices, the appropriate performance scored 1, and inappropriate or wrong performance was scored 0. The scores were converted to percentages (incompetent was from 30%-60%, and fair was more than 60% to less than 75% and, 75% or more considered competent bundle care strategies), were adopted with (**Hassan et al., 2021**).

Content validity:

Five specialists in pediatrics, critical care medicine, and pediatric nursing reviewed and verified the content and concurrent validity of the study tools. Researchers verified the tools based on the opinions of experts and feedback.

Pilot Study:

To evaluate the study tools' readability and the amount of time needed to complete the updated tools, ten participants were included in a pilot study. No additional changes were required considering the pilot study participants' feedback. The full study sample included the subjects who participated in the pilot study as well.

Tool's reliability:

Testing and retesting findings using Alpha Cronbach found that all items differed substantially and had correlation coefficients that were greater than the acceptable level of significance (r=0.82) for the knowledge tool. The alpha value for the performance checklist in the study sample was (r = 0.85). On the other hand, the newborn evaluation had an Alpha Cronbach coefficient of (r=0.79), indicating that the study tools were very reliable.

Ethical considerations

The current study received ethical approval from the Research Ethical Committee at the Faculty of Nursing, South Valley University. Additionally, official permission was granted by the director of Hurghada General Hospital. Before participation, oral consent was obtained from the nurses and parents of the newborns after thoroughly explaining the aim, tools, duration, and benefits of the study. The researchers assured the participants that their involvement in the study was voluntary, and that the confidentiality of their responses would be maintained.

Educational Program:

Pretest phase:

After seeking permission to conduct the study, data was collected from 50 nurses working in NICU Assessment of nurses' knowledge about VAP bundle and its prevention in NICU pre-educational program application was performed using tools (I, II, & III), as the researcher assessed demographic data of study sample through questionnaire related to their age, gender, professional qualification, years of experience in NICU and neonate`s gestational age, birth weight, admitted diagnosis, ….etc, and assessed the neonates undergoing artificial ventilation, then assessment of the nurse`s knowledge regarding prevention of VAP was done. As well as assessment of the nurse`s practices related to VAP bundle care was done through an observation checklist as the study sample (nurses) were observed through three shifts: morning, afternoon, and night shifts before the implementation of the program.

Intervention phase:

The implementation of the program was performed through educational sessions for the nurses about VAP, and its preventive measures and to demonstrate the bundle care for the assigned neonates. The program consisted of two sessions, each lasting 2 hours. Each session includes knowledge about ventilator-associated pneumonia, neonatal assessment, and practices that prevent ventilator-associated pneumonia. Powerpoint slides, posters, handouts, discussion, demonstration, and re-demonstration in addition questions were used for demonstrating the sessions. Ten nurses were assigned to each group based on their availability, and each group participated in the program for a week. The entire program spanned over 2 months. After finishing the educational sessions about VAP, its prevention, and demonstration of VAP bundle care inside the session, the researcher started to audit the nurses during a demonstration of VAP bundle care through three shifts; as each nurse was audited during morning, afternoon, and night shift, this clinical auditing for the nurses is a method to find out if healthcare is being provided in line with required standards according to that discussed during the educational sessions.

Posttest phase:

After the program had been implemented, the study sample was reassessed by using the three mentioned tools (nurses' knowledge, neonatal assessment, and VAP bundle care tools) to assess the nurses` knowledge, practices related to bundle care, and assessment of the neonatal outcome.

Statistical analysis:

The data entry and analysis software utilized was IBM SPSS version 32.0. The information was computerized. The quantitative variables were given means and standard deviations. The significant difference in proportion was assessed using different statistical tests. The Chi-square test and the Fisher test were employed to determine whether there is a significant link between categorical variables. In all statistical tests, a value of $P \leq 0.05$ was considered statistically significant.

Results

Table 1 displays that, 76.4% of the study sample (nurses) were females, with a mean age of 28.40 years. Approximately 61.8% them had a diploma in nursing, while only 1.8% held a master's degree, and none had a PhD. The mean years of experience for nurses in the NICU were 4.41years, and only 34.5% had attended a ventilator bundle training course. The table also indicates that prematurity was the leading cause (32.6%) for mechanical ventilation, while congenital anomalies had the lowest percentage (7.8%). Approximately 18.0% of the neonates were 15 days or older, and 47.2% of them weighed between (1.5 KG and 2 KG). Moreover, (52.8%) of the neonates spent 8 days or more in the NICU.

Table (2): shows that 31.5% of the neonates necessitated ventilation over 10 days before program implementation. This decreased to 7.9% after program implementation, signifying a statistically significant disparity after the program ($p \geq 0.001$). Moreover, there were noteworthy associations between neonatal hospital stay, the presence of complications, and antibiotic use, as evidenced by p-values of 0.001, 0.007, 0.034, 0.001, and 0.002, respectively, except for a positive culture for infection. As well as there was also a decrease in the cases of VAP

among neonates it declined from 54 to 28 cases after the program was implemented.

Table 3: reveals that there was a statistically significant correlation between nurses' knowledge about ventilator-associated pneumonia among neonates and extubating and weaning trials ($p \geq 0.064$ and 0.084 respectively) before and after the program implementation. In addition, there were improvements in the nurses' knowledge about the items of bundle care with a positive correlation before and after the program implementation except concerning extubating and weaning trials.

Table 4: Demonstrates the difference between the mean and SD of nurse's performance regarding bundle care before and after program implementation, as there was an increasing mean score of the nurses' performance after program implementation with a statistically significant difference, the mean scores of auditing nurses' performance were the highest on the afternoon and night shifts with statistically significant correlation before and after implementation.

Table 5: presents that, statistically significant positive association between the nurses' knowledge and practices regarding the implementation of bundle care for newborns under ventilation before and after the program's implementation with (p-value = 0.001 & 0.012 respectively). Moreover, a negative association has been observed between the nurses` knowledge with the presence of VAP cases with (p-value = -0.051) after program implementation.

Figure 1: points out that 43.6% of the nurses studied had satisfactory knowledge about VAP bundle care before program implementation and this percentage increased to 78.2% after program implementation.

Figure 2: illustrates that the highest percentage (47.3 %) showed incompetent performance before program implementation, compared to 20.0% of them after program implementation.

Table: 1 Percentage and distribution of sociodemographic characteristics of the studied nurses (n=55) and neonates undergoing ventilator n=(89).

Items	No	%
Age	**Mean ± SD** 28.40 ± **6.92**	
Gender		
Male	13	23.6
Female	42	76.4
Years of experience in NICU		
• < 1 yr	6	10.9
• 1 < 5yrs	28	50.9
• ≥ 5 yrs	21	38.2
Mean ± SD	**4.41 ± 3.04**	
Educational level		
• Diploma Nurse	34	61.8
• Bachelor's degree of nursing science	20	36.4
• Master's degree	1	1.8
• Doctorate degree	0	0.0
Attending ventilator bundle training		
• Yes	19	34.5
• No	36	65.5
Average of cases taken nursing care per shift	Mean+ SD	2.12 ± 0.61
Neonatal data:		
Diagnosis:		
Respiratory distress syndrome	25	28.1
Prematurity	29	32.6
Neonatal sepsis	16	18.0
Pneumonia	12	13.5
congenital anomalies	7	7.8
Gestational age	**Mean ± SD; 32.14 ± 3.05**	
Age: 2 < 7 days	49	55.1
1 Week < 15 Days	24	27.0
≥15 days	16	18.0
Birth weight		
< 1Kg	4	4.5
1 Kg < 1.5 Kg	33	37.1
1.5 Kg < 2 Kg	42	47.2
2 Kg or more	10	11.2
Length of stay in NICU		
2 – 4 days	17	19.1
5- 7 days	25	28.1
8 days or more	47	52.8

Table 2: Correlation between Neonatal assessment and outcome from bundle care before and after program intervention: n = (89).

Neonatal Assessment	Before Program		After Program		F-Test	P-Value
	No	%	No	%		
Duration of MV						
2 ≤ 5 days	24	27.0	42	47.2	20.19	0.001**
5 ≤ 10 days	37	41.6	40	44.9		
More than 10 days	28	31.5	7	7.9		
Increase hospital stay due to VAP:						
Yes	48	53.9	31	34.8	23.06	0.001**
No	41	46.1	58	65.2		
Presence of complications due to VAP						
Yes	59	66.3	35	39.3	25.34	0.007**
No	30	33.7	54	60.7		
Culture positive infection						
Yes	69	77.5	50	56.2	4.91	0.340
No	20	22.5	39	43.8		
CRP **Mean± SD**	**31.52±30.21**		**11.77 ± 9.95**		6.73	0.001**
Antibiotics used						
Yes	84	94.4	75	84.3	16.50	0.002**
No	5	5.6	14	15.7		
Presence of VAP among Neonates						
Yes	54	60.7	28	31.5	22.75	0.019*
No	35	39.3	61	68.5		

Table 3: Correlation Between Nurses' Knowledge About VAP and Its Bundle Care before and after Program Intervention n=(55).

	Before Program				After Program				X^2	P-Value
	Satisfactory		Un-Satisfactory		Satisfactory		Un-Satisfactory			
	No	%	No	%	No	%	No	%		
Nurses Knowledge about ventilator-associated pneumonia:										
Definition	17	30.9	38	69.1	32	58.2	23	41.8	17.68	0.000**
Signs and Symptoms	26	47.3	29	52.7	40	72.7	15	27.3	18.49	0.000**
Risk factors	19	34.5	36	65.5	23	41.8	32	58.2	12.10	0.064
Diagnostic procedures	19	34.5	36	65.5	30	54.5	25	45.5	24.19	0.000**
Functions of MV and how to deal with it	12	21.8	43	78.2	28	50.9	27	49.1	14.80	0.000**
Lab analysis	16	29.1	39	70.9	35	63.6	20	36.4	13.89	0.002**
Modes of MV	23	41.8	32	58.2	33	60.0	22	40.0	26.18	0.001**
Nurses Knowledge about VAP Bundle Care:										
Regular hand hygiene	30	54.5	25	45.5	38	69.1	17	30.9	29.5	0.008**
Positioning	32	58.2	23	41.8	36	65.5	19	34.5	36.8	0.000**
Oral care	20	36.4	35	63.6	19	34.5	36	65.5	28.7	0.000**
Ventilator care measures	19	34.5	36	65.5	30	55.5	25	45.5	26.02	0.000**
Suction	26	47.3	29	52.7	29	52.7	26	47.3	23.9	0.000**
Extubating and weaning trials	17	30.9	38	69.1	23	41.8	32	58.2	8.37	0.086
Prevention of peptic ulcer	21	38.2	34	61.8	40	72.7	15	27.3	12.93	0.000**

Table 4: Comparison Between Nurses' Performance Related to Bundle Care Auditing of Their Performance before And after Program Intervention n=(55).

Nurses' performance of VAP	Before Program Mean± SD	After Program Mean± SD	F-Test	P-Value
Bundle Care:				
Regular hand hygiene	4.12 ± 1.07	6.27 ± 0.78	22.48	0.050 *
Positioning	4.0 ± 1.23	5.07 ± 0.95	31.51	0.001 **
Oral care	3.74 ± 1.07	4.98 ± 1.04	25.95	0.004 **
Ventilator care measures	4.20 ± 1.11	7.15 ± 0.65	20.08	0.041 *
Suction	4.09 ± 1.12	5.29 ± 0.85	24.95	0.011 *
Extubating and weaning trials	3.42 ± 1.33	6.07 ± 0.86	18.74	0.112
Prevention of peptic ulcer	3.83 ± 1.34	5.25 ± 0.88	29.12	0.001 **
Lip moist and Peptic ulcer	4.1± 1.84	6.24± 1.09	22.15	0.023*
Nurses Performance Auditing:			**t-test**	
Morning Shift	8.72 ± 2.66	11.52 ± 1.42	9.10	0.001 **
Afternoon shift	9.43 ± 2.16	12.32 ± 1.24	11.63	0.001 **
Night shift	9.30 ± 1.98	12.34 ± 1.14	9.22	0.001 **
Total performance	**27.47** ± 4.49	**36.20** ± 2.79	**16.91**	**0.001** **

Table 5: Correlation Coefficient Between Total Nurses' Knowledge, Performances, Presence of VAP Cases, and Increased Hospital Stay among Neonates of AVP Bundle Care Among Neonates. Nurses n=(55) & neonates=(89).

Correlation coefficient	Nurses Knowledge about VAP Bundle Care			
	Before Program		After Program	
	r	P	r	P
Nurses' Practice Related to VAP Bundle Care	0.533	0.001**	0.336	0.012*
Presence of VAP cases among Neonates	0.767	0.041*	0.711	- 0.051*
Increase Neonatal Hospital Stay	0.960	- 0.007	0.330	0.134

Figure 1: Total Nurses' Knowledge About VAP Bundle Care before & after Program Implementation Among Neonates. n= 55

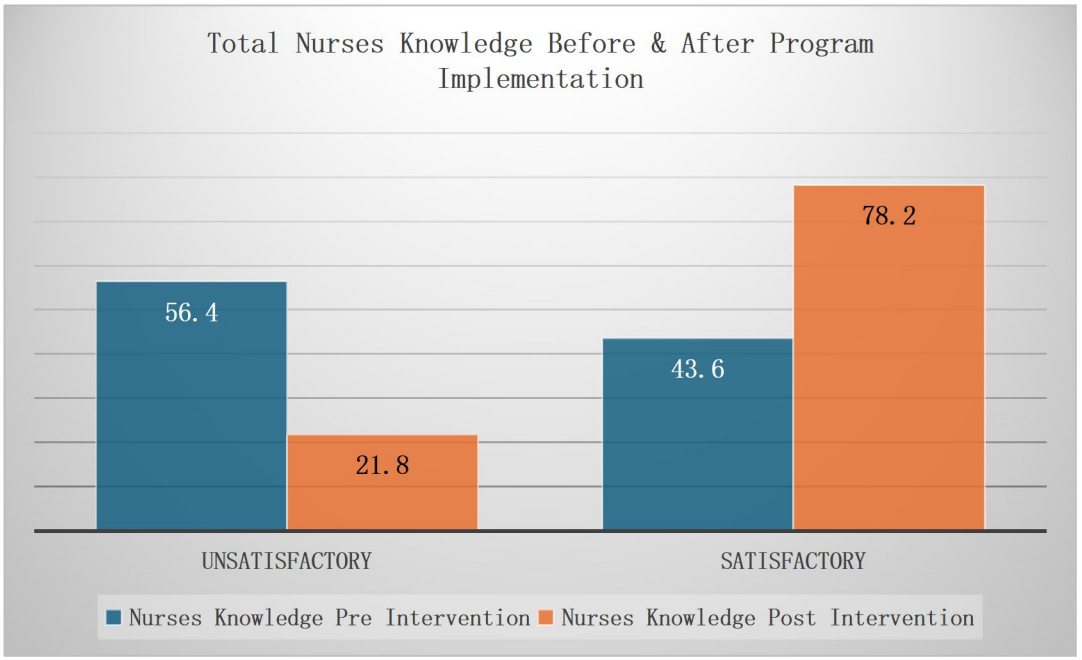
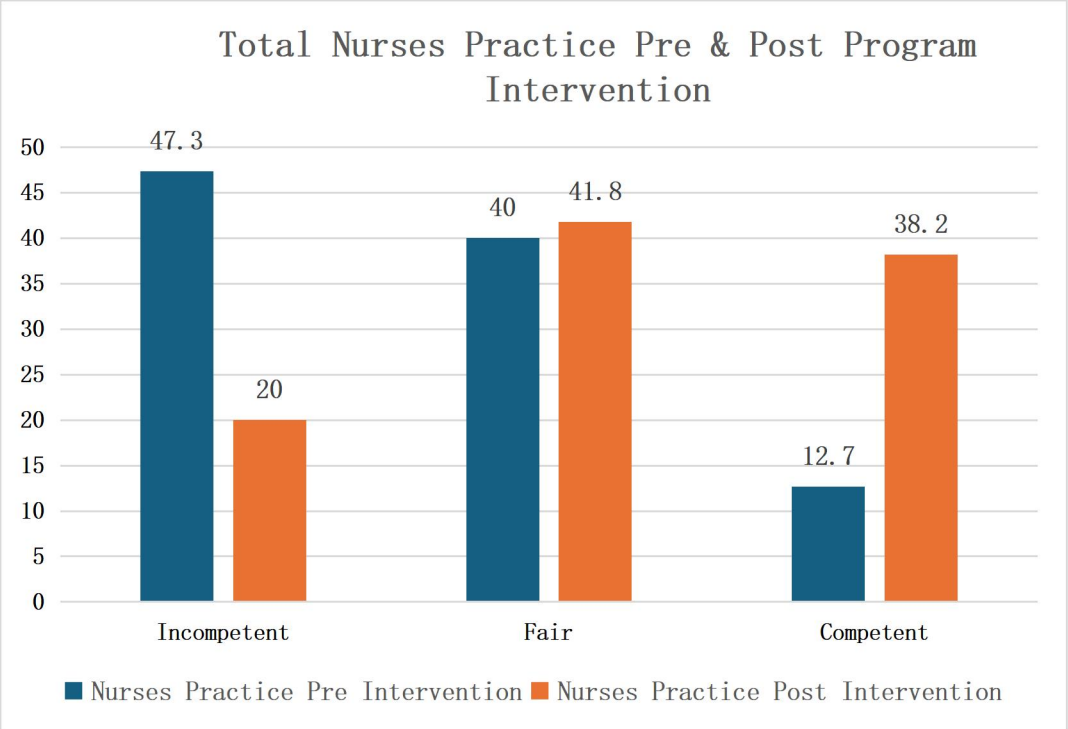


Figure 2: Total Nurses' Practice About VAP Bundle Care before & after Program Implementation Among Neonates. n = (55).



Discussion

The prevention, management, and treatment of hospital-acquired infections in neonates who are intubated are critical tasks performed by nurses in the Neonatal Intensive Care Unit (NICU). Healthcare providers must be properly educated on VAP preventive techniques to adhere to recommended regulations, and lower the risk of ventilated-associated pneumonia, in addition to lowering the morbidity and mortality rate of newborns in the NICU who are on mechanical ventilation (**Akl et al., 2020 & Khalil et al., 2021**). Implementing instructional strategies can improve health personnel's adherence to VAP prevention efforts especially nurses, leading to better neonatal outcomes and high-quality nursing care (**Mohamed et al., 2023 & Kallimath et al., 2024**). To avoid ventilator-associated pneumonia in babies in the neonatal intensive care unit, this study intends to measure the impact of intervention program on nurses' performance concerning care bundle strategies.

The present study's findings indicated that more than half of studied sample had diploma nursing degree, as well as held less than five years of NICU experience, and the highest majority of nurses didn't attend any training courses related to VAP, this was congruent to the study of **Abou Zed, and Mohammed (2019)** as their study conducted in Egypt cleared that; almost half of the nurses in the study worked in NICUs for less than five years, and most of them didn`t attended any prior training on preventing ventilator-associated pneumonia in newborns.

Concerning the duration of VAP and its complications, it has been significantly reduced, along with a marked decline in the neonate's CRP mean and the length of their hospital stay as well. It might be attributed to the beneficial effects of the VAP bundle care intervention program on the nurses and its impact on the newborns; as approximately one-third of the neonates spent more than ten days on mechanical ventilation (MV) before program implementation which is decreased

after its implementation with statistically significant positive correlation. This was consistent with **Aelami et al., (2014)** whose study was in Switzerland, **and Rangelova et al** ., (**2020**), in Bulgarian who explained that the training program appeared to be efficient in enhancing the nurses' understanding and utilization of preventive measures for ventilator-associated pneumonia in neonates. **Aelami et al., (2014)** illustrated that in the study after ventilator days, the rate of VAP dropped from 48.8/1000 to 25.7/1000 then again to 18.5/1000 following the application of a bundle of comprehensive preventive measures in Switzerland.

As for the blood culture of newborns, it was positive in the majority of them before program implementation, but it decreased somewhat after the program implementation, which might be attributed to, neonates having other infectious agents in addition to reasons for staying in the NICU. This result was similar to the research of **Gohr et al ., (2021)** who mentioned that, in their study applied in Egypt, the highest percentage of neonates had positive blood cultures before program intervention.

The ultimate goal of nursing continuing education is to improve the quality of care provided to newborns (**Abad et al., 2021**). The results of the present study indicated that nurses' knowledge about VAP among neonates was enhanced after implementing the educational program regarding VAP meaning, signs and symptoms, risk factors, diagnostic procedures, functions of mechanical ventilation, and how to deal with its modes, interpretation of neonatal lab tests, and the knowledge about VAP bundle care and demonstrated that there were obviously differences in the nurses' knowledge before and after the educational program intervention. These results were in the same line with **Amin et al., (2021)** in Egypt **& Alriyamj et al., (2022)** whose study done in a medical center in Pittsburgh, Pennsylvania, who clarified that, after the training program, the nurses had an excellent level of knowledge. This was because the bulk of the studied nurses graduated from nursing diploma programs, which demonstrated how the nurses' VAP bundle training program improved the nurses' knowledge of neonatal VAP preventive measures. Also this was in agreement with **Madhuvu et al., (2020)** and **Katoch et al ., (2021)** who mentioned that one major obstacle for preventing VAP may be the nurse's inadequate knowledge of the VAP preventive care bundle and the suitable action among neonates in their studies that conducted in Australia and India respectively.

The present study explained that the training program has a significant positive influence on nurses' implementation of VAP bundle care practices. Following the program, the nurses' mean scores increased greatly, signifying a statistically significant correlation in their performance across all shifts (morning, afternoon, and night). This improvement in nurses' practices was also associated with improved neonatal health outcomes, decreased hospital stays as well as prevention or decreased incidence of further cases of VAP following program implementation these results were consistent with **González et al**., **(2021),** as the study performed in Spain demonstrated that, the preventative strategy decreased VAP rates from 12.89 episodes/1000 ventilator days to 1.31, which indicated high adherence to VAP bundle care to neonates. In addition, **Dipanjali et al., (2020)** who conducted their study in India & **Abiramalatha et al**., **(2021)** in the research applied in India, explained in their study that, the educational intervention had a positive effect on the knowledge and practice of the staff nurses on the prevention of VAP among intubated neonates, as evidenced by appropriate bundle care as well. Also; they mentioned that the nurses' knowledge and practice scores improved following the educational sessions. Similar studies have been reported to further reduce the prevalence of VAP in other trials, however, this could be related to a greater incidence of VAP cases before bundle care as cited by **Alriyami et al., (2022)** in a medical center in Pittsburgh, Pennsylvania**.** However, this improvement decreased in the follow-up, and a lack of supplies, continuous training, and a documented VAP care bundle strategy in the NICU could all be contributing factors to this decline in performance among nurses.

The current study indicated that the educational intervention significantly improved

staff nurses' knowledge and practice in preventing VAP in newborns and its appropriate bundle care, as the study findings approved that about half of the studied nurses had poor practice scores concerning the protective care bundle of intubated neonates before the implementation of the program. These practices related to bundle care are markedly improved after the program implementation. This was congruent with **González et al., (2021)**, who stated that every one of the bundle care measures was nominated as closely indicated by NICU protocol led to a decrease in VAP incidence among the studied neonates in Spain. The knowledge and practices of nurses were positively correlated before and after the program implementation, with a statistically significant correlation these results were well-matched with **Metwally et al ., (2020)** & **Amin et al., (2021)** who illustrate that, there was a highly significant difference in the nurses' performance and knowledge regarding the VAP care bundle. This might result from how effectively the program was implemented in their studies that were done in Egypt.

Limitations of the Study:

Hurghada General Hospital is an exclusive healthcare facility in the Red Sea region that features a dedicated nursery for newborns. The hospital has established a well-equipped area with an adequate number of incubators, nurses, and newborns. At the same time, it is a remote governorate, as some nurses withdrew from the study because they returned to their homes and original governorates, which led to replacing them with new nurses and repeating the program for them with the same steps, that resulted in extending the implementation period of the program.

Conclusion

The study revealed that a bundle approach to prevent VAP in neonates significantly reduces incidence and promotes clinical improvement. The study found that nurses demonstrated improved knowledge and practice levels after implementing the preventive care bundle program, with a significant improvement compared to before program intervention. Furthermore, a favorable association was observed between the overall knowledge and practice scores of nurses before and after the implementation of the preventive care bundle approaches.

Recommendations:

As per the results of the current study, it was recommended that:

- Regular auditing for nurses during practice to achieve the highest performance quality as the nurses' knowledge improved better than their practices.
- Providing the necessary consumables and assets to perform the required VAP bundle care, because it was noted that sometimes the reason for not following the constructed bundle care is the lack of consumables or assets.
- Repeating the same program but including their behavior and attitude related to VAP bundle care as it was noted that nurses were working but only implementing without believing in what they were doing.
- The VAP preventive care bundle should be covered in the orientation program for newly hired NICU nurses.
- Every neonatal intensive care unit should include manuals, information pamphlets, and self-instruction modules about VAP preventative care bundles.

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