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Effect of Preventive Bundle Guidelines on Reducing Iatrogenic Pressure Injuries among Critically Ill Neonates

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Abstract: Background: There is an emerging awareness that acutely ill and immobilized neonates are at risk for iatrogenic pressure injury. Therefore, it is crucial for nurses to understand the physiologic indices of pressure injury development and their interventions should be based on evidence-based information to reduce neonatal morbidity and mortality while increasing quality of care in the neonatal care setting. **The aim of this study** was to evaluate the effectiveness of preventive bundle guidelines on reducing iatrogenic pressure injuries among critically ill neonates. **Research design:** A quasi-experimental design was used. **Settings:** This study was conducted at the neonatal intensive care units in Benha Specialized Pediatric Hospital. **Sample:** A Convenient sample of nurses' (n=50) and critically ill neonates (n=60) were included from the above mentioned setting. Those neonates were divided equally into two groups (study and control). **Tools of data collection:** Four tools were used namely; structured interviewing questionnaire format, pressure injury preventive bundle compliance checklist, Braden Q Risk Assessment Scales, and nurses opinion likert scale. **Results:** High percentage of the neonates (76.7% & 83.3%), in the study group were not at risk of pressure injury in the first and second week of admission respectively; this increased to 90.0% before discharge. While around (40%) of neonates in the control group were at high risk of pressure injury from the first week of admission till before discharge. Moreover, the result revealed that there was a significant improvement in nurses knowledge regarding pressure injuries as well as their compliance with preventive bundle guidelines after bundle implementation. **Conclusion:** The implementation of preventive bundle guidelines proved to be effective in improving nurses' knowledge and their compliance, with a positive impact on the incidence of pressure injury among critically ill neonates. **Recommendation:** Preventive bundle guidelines should be implemented in all hospitals caring for children to reduce the harm associated with hospital-acquired pressure injuries.

Keywords: Preventive bundle guidelines, critically ill neonates, iatrogenic pressure injury

INTRODUCTION

Hospitalized neonates are at risk for iatrogenic pressure injuries (hospital-acquired condition) due to the immature skin, compromised perfusion, decreased mobility, altered neurological responsiveness, fluid retention, moisture, and medical devices¹. Pressure injuries among neonates are increasingly recognized as a significant cause of morbidity and can add considerably to the cost of hospitalization². Worldwide, Pressure injury incidence ranging from 3.70 to 21.60% in the neonatal intensive care units, with a prevalence of 23% and most injuries occurring within two days of admission^{3,4}.

The skin is a membrane under continuous development in the neonate. It has a vital role in the neonatal period, as it provides a protective barrier that helps to prevent infections, facilitates thermoregulation and helps to control the insensible water loss and electrolyte balance⁵. Injury of skin can lead to local or systemic infection, pain, disfigurement, mortality as well as increased costs, prolonged hospitalization and negative psychosocial implications associated with secondary scarring⁶.

Although full-term neonates' have a fully functioning skin barrier that prevents organ dehydration, their skin is not yet mature and continues to change and develop during the first year of life. As a result, neonate skin is not as resilient as adult skin, and at a risk for increased absorption of agents

that can be absorbed through the skin and much more susceptible to skin injury. So, its unique properties should be taken into account in order to maintain the integrity of the neonate skin barrier^{7,8}. Additionally, It is necessary to focus nursing care on restoring the normal functions of the skin or alleviating its immaturity until the neonate skin is completely developed⁹.

Iatrogenic pressure injuries (PIs) are identified as never events acquired during the hospital stay. Results show that 50-85% of iatrogenic PIs are preventable but, the financial costs for these events are high. Furthermore, prevention and treatment can consume limited resources in large quantities, including nursing care and money¹⁰. A systemic review argued that the cost of pressure injuries treatment is much higher than prevention. Therefore, additional attention paid to PIs is likely to improve neonate care and reduce the economic costs associated with treatment¹¹.

According to¹² pressure injury is localized damage to the skin and underlying soft tissue usually over a bony prominence or related to a medical or other devices. The injury can present as intact skin or an open ulcer and may be painful. The injury occurs as a result of prolonged pressure or pressure in combination with shear and or/ friction. The tolerance of soft tissue for pressure and shear may also be affected by microclimate, nutrition, perfusion, co-morbidities, and condition of the soft tissue.

The main risk factors of PIs at neonates are the use of therapeutic and diagnostic devices (50–90% of the PIs in neonates), the presence of endotracheal tube, use of noninvasive mechanical ventilation, hypotension and hypoxemia, prolonged stay in the neonatal intensive care unit, low birth weight and prematurity¹. The most frequent locations of pressure injuries in neonates are the occipital region and ears,^{13,14} as well as anatomical areas where therapeutic or diagnostic systems are at risk, such as fingers and feet, skin support areas, thorax, ear lobe, nasal septum, back of the neck, nostrils, and cheeks¹⁵.

Pressure injuries are classified by¹⁶ into four categories. As for category I, a non-blanching erythema is produced on intact skin; in category II, there is a partial loss of skin thickness or blisters may appear; in category III, there is a total loss of skin thickness; and in category IV, there is total loss of tissue thickness, with exposed muscle or bone. Besides these four categories, The National Pressure Ulcer Advisory Panel describes two additional categories: the fifth category is the “unclassifiable”, in which there is a total loss of the skin or tissue thickness, and depth is unknown; The sixth category is the “suspected deep tissue injury”, with unknown depth¹⁷.

Using care bundle to avoid hospital acquired conditions is a quality improvement methodology that is gaining increasing recognition. A bundle is a set of interventions preferably evidence-based, intended for a defined patient population and care setting that, when implemented together will result in better outcomes than implemented individually. Typically, a bundle has 3-6 relatively independent elements that are accepted by clinicians as care that should be delivered as usual practice¹⁸.

Protecting skin integrity is a major part of nurses' work and they are obliged to use their clinical knowledge and experience to prevent skin and tissue injury. According to¹⁹ it is crucial for nurses to understand the physiologic indices of pressure injury development and their interventions should be based on the evidence-based information. Identification of true risk factors must be accomplishable for nurses in order to prevent neonates from unnecessary suffering but also to avoid unnecessary expenses by applying needless preventative measures.

Pediatric critical care nurses must identify the appropriate interventions to prevent pressure injury development. They must continuously educate themselves to ensure that they are knowledgeable concerning the manufacturers' recommendations for all devices used in the care of the neonates. When suspecting that a neonate is at risk of pressure injuries, the nurse should promptly report this information to the responsible physicians, examine the neonate and take appropriate measurements²⁰.

SIGNIFICANCE OF STUDY

Critically ill neonates managed in an intensive care unit (ICU) may experience multiple physiological changes directly related to their illness and possibly their care. The majority of ICU neonates are ventilated or sedated and therefore, unable to care for themselves, move or change position. Moreover, extensive exposure to pressure,

from lying on a specific part of the body renders neonates at greater risk of skin injury. So, the vulnerability of these neonates places them at high risk of impaired skin integrity, particularly iatrogenic pressure injuries development^{21,22,23}.

Hospital acquired pressure injuries are a big problem significantly increase morbidity, mortality and financial burden. Despite hospital are facing an increased demand to prevent iatrogenic pressure injuries among actually ill and immobilized neonates, most of prevention and treatment protocols are extrapolated from adult practice guideline. No specific studies have been conducted in this population. In fact, many health professionals believe that pressure injuries are not a problem in the neonates' population. This belief becomes a major risk factor because the skin may not be assessed and prevention measures may not be implemented²⁴. Thus, evidence-linked clinical practice guidelines for prevention and treatment of iatrogenic pressure injuries that specifically address the neonatal population are needed.

Therefore, The researchers found urgent to conduct this research to increase nurses' knowledge and improving their compliance for prevention and management of pressure injuries. Meanwhile, neonate outcomes may potentially improve by reducing iatrogenic pressure injuries rates. This reduction will contribute to lower costs, less hospital stay and increased quality of care for healthcare professionals.

AIM OF THE STUDY

The aim of this study was to evaluate the effectiveness of preventive bundle guidelines on reducing iatrogenic pressure injuries among critically ill neonates through:

1. Assessing nurses' knowledge regarding pressure injury.
2. Assessing nurses' compliance with preventive bundle guideline
3. Designing and implementing preventive bundle guidelines for nurses who provide care to critically ill neonates.
4. Evaluating the effect of preventive bundle guidelines on nurses knowledge, compliance and incidence of iatrogenic pressure injury of critically ill neonates.

RESEARCH HYPOTHESES

1. The level of Nurses knowledge will be increased significantly after implementing preventive bundle guidelines.
2. The level of nurses' compliance will be improved significantly after implementing preventive bundle guidelines.
3. There will be a statistically significant correlation between nurses' knowledge, and compliance scores and their personal characteristics after bundle implementation.
4. Critically ill neonates (study group) who had care according to preventive bundle guidelines will have less iatrogenic pressure injury than those in the control group.

SUBJECTS AND METHOD

Technical Design:

Research Design: A quasi-experimental design was utilized to achieve the aim of this study.

Research Settings: This study was conducted in neonatal intensive care units at Benha specialized pediatric hospital affiliated to the ministry of health and population.

Subjects: The study subject consisted of two groups:

First group: -A Convenient sample of nurses (n=50) worked at the above mentioned hospitals in morning and afternoon shifts regardless their characteristics in a period of six months.

Second group: -A convenience sample of 60 critically ill neonates was included from the previously mentioned settings. Those neonates were divided equally into 2 constructed groups; study group (n=30) who had care according to a preventive bundle guidelines and control group (n=30) who had care according to a hospital routine.

The exclusion criteria: Neonates with pressure ulcer at admission

Tools of Data Collection:

Tool I: A structured interviewing questionnaire format: It was designed by the researchers in the Arabic language after reviewing of the related literatures to assess nurse's knowledge regarding pressure injuries. It comprised four main parts which are:

Part I: Personal characteristics of the studied nurses such as; age, gender, qualification, years of experience, attainment of training courses related to iatrogenic pressure injuries and availability of preventive bundle guidelines for pressure injury prevention.

Part II: Personal characteristics of the studied neonates such as; age, gender, diagnosis and duration of hospital stay.

Part III: Nurses' knowledge regarding pressure injuries: It include 14 Multiple-choice questions related to structure of skin (1), function of skin (1), methods use for skin assessment (1), common skin problems (1), definition of pressure injury (1), classification of pressure injury (1), features of each pressure injury stage (4), common sites of pressure injury (1), risk factors of pressure injuries development (1), factors that contribute to pressure injury development (1), and pressure injury prevention (1).

Scoring system for knowledge: Nurses' knowledge were evaluated upon completion of the interview questionnaire as the studied nurses' knowledge was checked with a model answer and accordingly, the correct answer was given one score and zero for incorrect or don't know answers. The total score was ranged from 0-14. Then, their total knowledge were categorized as score of 80% and more was considered good, a score between 60% to less than 80% was considered average, while a score below 60%. was considered poor.

Part IV: Nurses' knowledge regarding bundle barriers: It was adapted by researchers based on **Tayyib et al., (2016a)**²⁵ to assess nurses' barrier for application of preventive bundle guidelines in neonatal intensive care units and assessed before the intervention only. It includes 9 items on a scale of 0 to 9 with 0 being not a barrier and 9 being a major barrier.

Tool II: Pressure injury prevention bundle compliance checklist: It was adopted from **Tayyib et al., (2016b)**²⁶ and **Visscher et al., (2013)**²⁷ to assess nurses compliance towards pressure injury preventive bundle guidelines. It includes 34 steps and covered six dimensions named: Risk Assessment (3), Skin Assessment (7), moisture management (8), care of medical devices (5), Nutrition (1) and repositioning (10).

Scoring system for pressure injury prevention bundle compliance checklist: Give a score of one for comply, and a score of zero for not comply. Total scores converted into percent scores, where the score of $\geq 80\%$ considered a satisfactory level of compliance and a score $< 80\%$ considered an unsatisfactory level of compliance.

Tool III: -Braden Q Risk Assessment Scales : It was validated and developed by **Quigley and Curley, (1996)**²⁸ to assess the neonates' risk for pressure injury. It consisted of seven subscales named; mobility, activity, sensory perception, moisture, friction/shear, nutrition, and tissue perfusion/oxygenation. Each subscale is rated one- to four-point rating scale, with the lowest number representing the highest risk. Total scores range from 7-28 with 7 putting a child at the highest risk for skin breakdown and 28 with no risk. The cut-off score indicating risk is 16 or less. The scores of all items were summed-up and divided as the following: Mild risk 16-23, Moderate risk 13-15, High risk 16 or below and Very high risk 9 or below.

Tool IV: Nurses Opinion Likert Scale: It was adapted from the researcher from **Konstantin, (2017)**²⁹ to assess nurses experience gained from the practice of preventive bundle guidelines. It consists of 6 statements such as; I am more knowledgeable about pressure injury prevention today than I was before, I am more knowledgeable about pressure injury classifications now than before, & I am more comfortable implementing preventive bundle guidelines now than I was before, with a five-point likert scale ranging from "strongly agree" to "strongly disagree." The responses were dichotomized into two categories: "strongly agree/agree" and "strongly disagree/disagree/agree nor disagree".

Operational Design:

Preparatory Phase:

A review of the past and currently available literatures in various aspects of the problem using books, evidence-based articles, periodicals, and magazines were done to be acquainted with all aspects of the study problem and also in order to develop relevant tools for data collection and the content of the preventive bundle guidelines. This period extended from May to July 2017.

Tool validity and reliability:

Tools validity were tested through a jury of three experts of Pediatric Nursing field from the Faculty of Nursing, Ain Shams, and Zagazig Universities, to test the tool clarity, relevance, comprehensiveness, simplicity and applicability. Modifications of the tools were done according to the expert's judgment on the clarity of sentences, appropriateness of content and sequence of items. The experts 'agreed on the content, according to their review a few modifications were carried out in the content. The suggested changes were made. Internal consistency reliability of all items of the tools was assessed using coefficient alpha. It was 0.83 for Structured Interviewed Questionnaires format, 0.87 for compliance checklist and 0.82 for nurses opinion Likert scale. This phase took a period of time from August to September 2017.

Ethical Considerations:

A permission to carry out the study was obtained from the hospital manager and head of intensive care units in the previously mentioned study settings through submission of an official letter issued from the dean of Faculty of Nursing, Benha University. Oral consent was obtained from nurses after explaining the purpose of the study. Nurses were also informed that participation in the study was voluntary. Each one had the right to withdraw from the study at any time without giving any reason. Confidentiality of participants' information was assured and the data were accessed only by the researchers involved in the study.

Pilot Study:

The pilot study was carried out on 5 nurses and 6 neonates (3 for study and 3 for control groups) representing 10.0% of the study subject over a period of one month (October, 2017). The purpose was to ascertain the feasibility of the study, the clarity, and applicability of the tools. It also helped to estimate the time needed for filling out the forms. Based on the results of the pilot, the necessary modifications on the study tools were done and pilot study subjects were excluded from the sample of the study.

Field work:

Assessment phase: The actual field work was carried out from the beginning of November, 2017 to the end of March, 2018. The researchers were available at the previously mentioned settings four days/week (Saturday to Tuesday) in the neonatal intensive care units from 8AM-2PM and the average number interviewed was 4-5 participant / day. At the beginning of the interview, the researchers greeted the nurses, introduced themselves to each participant included in the study, explained all information about the study purpose, duration, and activities and took an oral consent. Then, each nurse was asked to fill the data collection tool individually to collect baseline data and to assess nurses' needs (Tool I). At the same time, the researchers observed each nurse during demonstrating routine skin care for critically ill neonates to measure bundle compliance (Tool II). The time required for completing the study tools ranged between 20-30 minutes. Meanwhile, The researchers started to assess neonates skin condition for risk of pressure injury in the control group after applying skin care by nurses (hospital routine care) weekly for three times

(1st week of admission, 2nd week of admission and before discharge) by using Braden Q scale (Tool III). This phase took about one month and a half.

Planning phase: The preventive bundle guidelines was designed by the researchers after an extensive review of related literatures and the needs identified in the assessment phase. An Arabic booklet concerning pressure injuries preventive bundle guidelines was prepared and given to nurses.

Implementation phase: The preventive bundle guidelines was implemented in about two months. it was carried out in 6 sessions (2 sessions for theory and 4 sessions for practice). A time schedule suitable for nurses was developed to conduct the program that includes; date, place, topic, time and duration of each session. The training program consisted of two parts, the theoretical part cover (skin structure and function, common skin problem, methods of skin assessment, definition of pressure injury, classification, features of each pressure injury stage, common sites, risk factors, factors contributed to pressure injury and prevention) and the practical parts cover the items of preventive bundle (risk assessment, skin assessment, moisture management, care of medical devices, reposition and nutrition). These sessions have lasted for 11 hours. It was difficult to take all nurses at the same time; thus they were divided into 8 groups of about 5-6 nurses in every session.

The duration of each theory session started from 9.00 to 10.30 AM and from 11.00 AM to 1.00 PM for practical sessions four days/week. At the beginning of each session, the researchers started by a summary about what was given through the previous session and objectives of the new one, taking into consideration using simple and clear language to suit the nurses. Different teaching methods were used including small group discussion, lectures, brainstorming, role-playing, demonstration, and re-demonstration. The teaching aids used were colored posters, and PowerPoint presentation. Each nurse of all studied groups obtained a copy of preventive bundle handout explaining all elements in an Arabic language. An open channel communication was achieved between researchers and nurses to ensure understanding, answer any question and to verify the information given.

Evaluation Phase: After the completion of the program contents; Then nurses' knowledge and their compliance with preventive bundle guidelines were evaluated immediately, and after one month (follow up) by using same pretest tools. Additionally, the researchers asked nurses to apply preventive bundle guidelines on neonates (study group) and evaluate their skin condition for risk of pressure injuries weekly for three times (1st week of admission, 2nd week of admission and before discharge) by Braden Q scale (tool III). Then, the researchers asked nurses to assess their opinion regarding preventive bundle guidelines (Tool IV).

Statistical analysis of data: The collected data were categorized, tabulated, and analyzed using the SPSS computer program Version 21. Numerical data were

expressed as the mean and standard deviation. Qualitative data were expressed as frequency and percentage. A comparison between qualitative variables carried out by using a parametric Chi-square test. Correlation among

variables was done using Pearson correlation coefficient. P-value $\leq 0.05, 0.01, 0.001$ were used as the cut of value for statistical significance.

RESULTS

Table (1): Distribution of Nurses' Personal Characteristics (N=50).

Characteristics	Study sample n=50	
	No	%
Age in years		
- 20 - <25	20	40.0
- 25 - <30	27	54.0
- 30< 35	3	6.0
Mean \pmSD: 25.12 \pm 2.47		
Educational level		
- Diploma in nursing	37	74.0
- Technical institute of nursing	5	10.0
- Bachelor degree	8	16.0
Years of experience		
- <3	9	18.0
- 3<7	36	72.0
- ≥ 7	5	10.0
Mean \pmSD: 5.18\pm 2.37		
Attendance of any previous training courses regarding pressure injuries		
- Yes	0	0.0
- No	50	100.0

Table (1) shows the nurses' personal characteristics; it was observed that, the mean age of them was 25.12 ± 2.47 years. In relation to nurses' education, 74.0% of them had a diploma in nursing, while 16.0% of them had Bachelor degree in nursing and the remaining (10.0%) of nurses

graduated from a technical institute of nursing. Additionally, it was noticed that, nearly three quarter (72.0%) of nurses had an experience ranged from 3 to less than 7 years, and 100.0% of them not attended any previous training courses regarding pressure injuries.

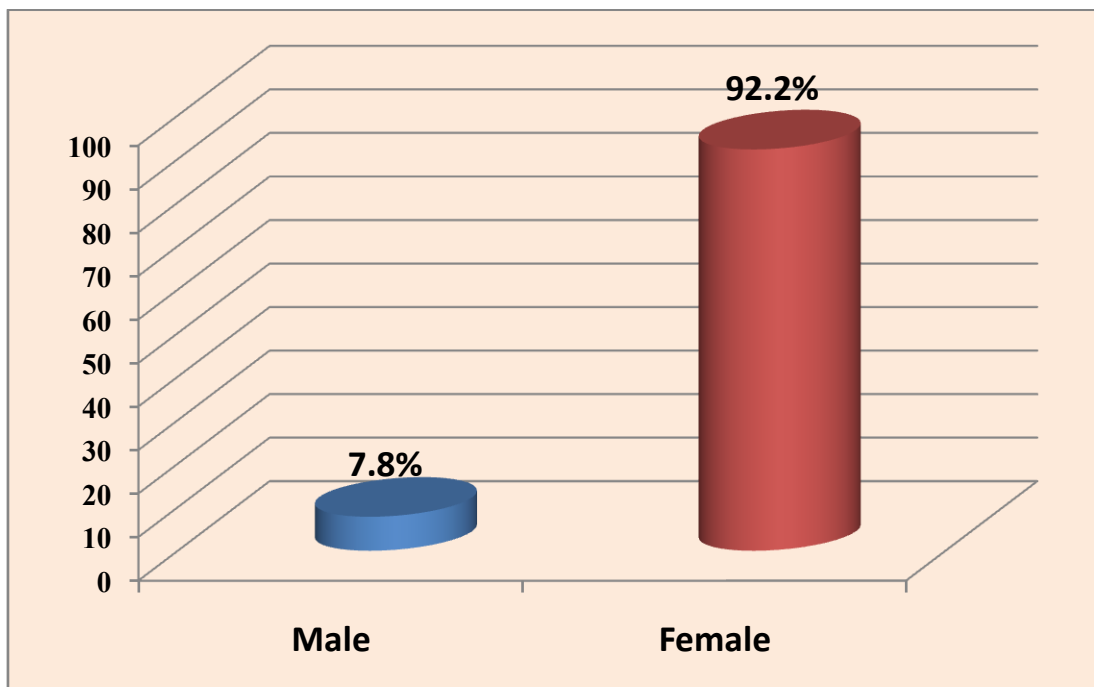


Figure (1): Distribution of the studied nurses according to their gender (N=50)

Figure (1) illustrates that, the majority (92.2%) of the studies nurses were females and the rest of (7.8%) of them were male

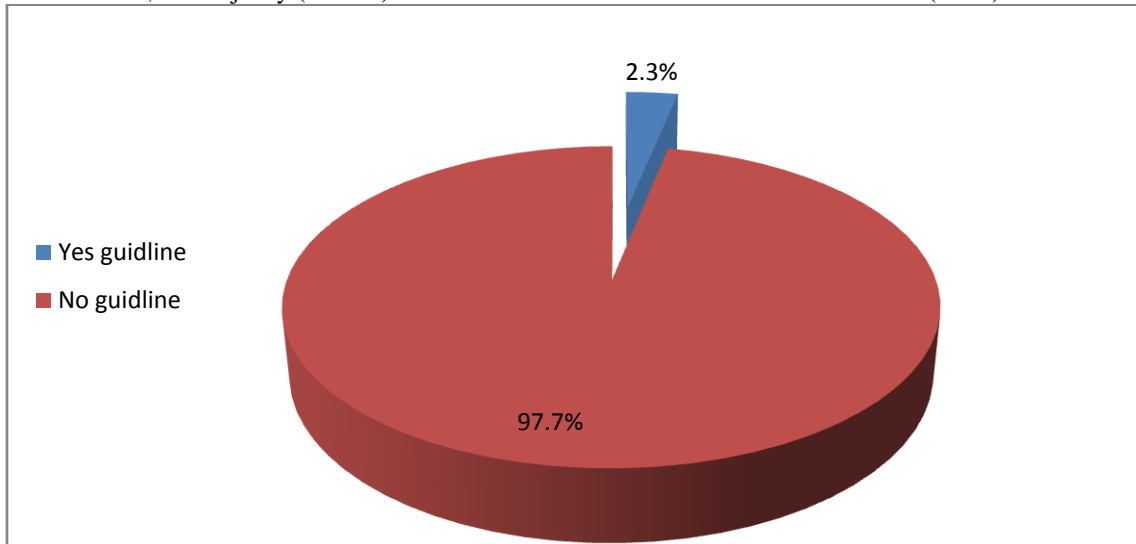


Figure (2): Availability of Preventive Bundle Guidelines for Prevention of Pressure Injuries as Reported by Nurses (N=50).

Figure (2) shows the availability of preventive bundle guidelines for prevention of pressure injuries as reported by nurses. It was illustrated that 97.7% of the studied nurses

reported that there are no available preventive bundle guidelines for prevention of pressure injuries at neonatal intensive care units.

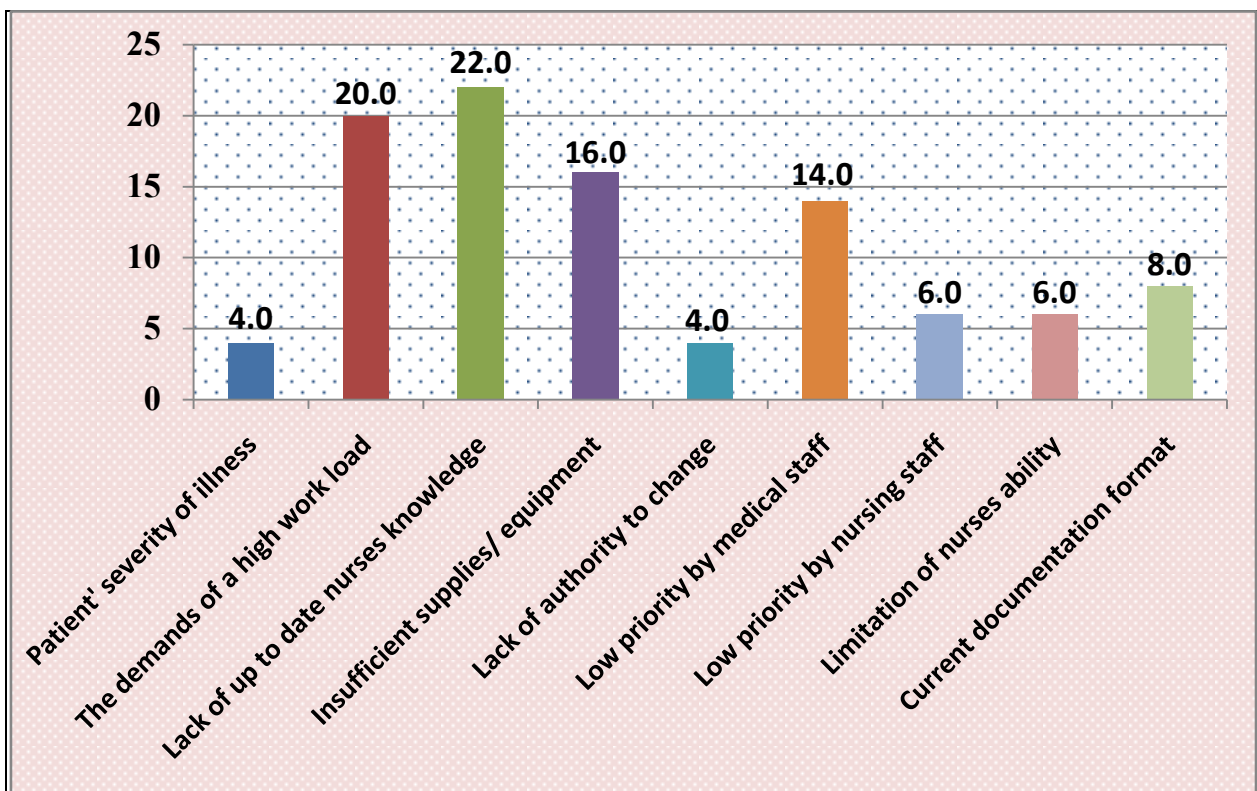


Figure (3): Barriers of Applying Preventive Bundle Guidelines As reported by Nurses

(N= 50)

Figure (3) shows barriers of applying preventive bundle guidelines as reported by nurses. It was revealed that, lack of up-to-date knowledge, the demands of a high workload,

and insufficient supplies and equipment were the most common barrier to applying preventive bundle guidelines in Intensive Care Unit (22.0%, 20.0% & 16.0%) respectively.

Table (2): Distribution of the Studied Neonates According to their Personal Characteristics (N=60).

Characteristics	Study group n=30		Control group n=30		Chi square test	P value
	No	%	No	%		
Gestational Age (weeks)						
<28	4	13.4	5	16.7	0.314	0.135
28-33	16	53.3	16	53.3		
34-37	10	33.3	9	30.0		
- (Mean ±SD)	32.19±2.07		31.98±2.14			
Gender						
- Male	8	26.7	12	40.0	0.313	0.362
- Female	22	73.3	18	60.0		
Diagnosis						
- RDS	13	43.3	12	40.0	0.228	0.567
- Pneumothorax	3	10.0	3	10.0		
- Convulsion	2	6.7	2	6.7		
- Apnea of prematurity	3	10.0	3	10.0		
- Congenital anomalies	3	10.0	5	13.3		
- Low birth weight	6	20.0	5	16.7		
Duration of hospitalization						
- Less than one month	14	46.7	15	50.0	7.939	0.160
- One month- < 2months	13	43.3	13	33.3		
- ≥ 2 months	3	10.0	5	16.7		
- (Mean ±SD)	29.63±15.60		28.33±9.71			

Table (2) illustrates the personal characteristics of children under the study; it was observed that, the mean age were (32.19±2.07 & 31.98±2.14 weeks) in the study and the control groups respectively. Nearly, three quarter and two third (73.3% & 60.0%) of them were female in both study and control groups respectively. Concerning neonates' diagnosis, less than half (43.3% & 40.0%) of the study and the control groups respectively were suffering from

respiratory distress syndrome. Additionally, the same table manifests that, the mean duration of hospitalization were 29.63±15.60 and 28.33±9.71 in both the study and the control groups respectively. Moreover, this table reveals that, there was no statistically significant difference between the study and the control groups related to all personal characteristics.

Table (3): Distribution of the Nurses' Knowledge Regarding Pressure Injuries Before, Immediately After and After one month of the Bundle Implementation (N=50).

Items of Knowledge	before (n=50)				Immediately after (n=50)				After one month (n=50)				x ²	P value
	Correct Answer		Incorrect answer and don't know		Correct Answer		Incorrect answer and don't know		Correct Answer		Incorrect answer and don't know			
	No	%	No	%	No	%	No	%	No	%	No	%		
1. Structure of skin	7	14.0	43	86.0	42	84.0	7	14.0	34	68.0	16	32.0	33.41	0.001**
2. Function of skin	3	6.0	47	94.0	46	92.0	4	8.0	32	64.0	18	36.0	38.19	0.001**
3. Methods use for skin assessment	1	2.0	49	98.0	45	90.0	2	4.0	30	60.0	20	40.0	40.11	0.001**
4. Common skin problems	7	14.0	42	84.0	46	92.0	4	8.0	35	70.0	15	30.0	36.08	0.001**
5. Definition of pressure injury	8	16.0	42	84.0	46	92.0	4	8.0	33	66.0	17	34.0	32.74	0.001**
6. Classification of pressure injuries	7	14.0	42	84.0	46	92.0	4	8.0	32	64.0	18	36.0	31.73	0.001**
7. Feature of first degree pressure injury	6	12.0	44	88.0	45	90.0	5	10.0	36	72.0	14	28.0	30.24	0.001**
8. Feature of second degree pressure injury	7	14.0	43	86.0	45	90.0	5	10.0	30	60.0	20	40.0	31.55	0.001**
9. Feature of third degree pressure injury	8	16.0	42	84.0	43	86.0	7	14.0	31	62.0	19	38.0	28.95	0.001**

10. Feature of fourth degree pressure injury	7	14.0	43	86.0	42	84.0	8	16.0	33	66.0	17	34.0	42.16	0.001**
11. Common sites of pressure injuries	8	16.0	42	84.0	46	92.0	4	8.0	38	76.0	12	24.0	29.98	0.001*
12. Risk factors of pressure injuries development	6	12.0	44	88.0	40	80.0	10	20.0	35	70.0	15	30.0	30.75	0.001**
13. Factors that contribute to pressure injuries development	7	14.0	43	86.0	40	80.0	10	20.0	35	70.0	15	30.0	29.05	0.001**
14. Pressure injuries prevention	10	20.0	40	80.0	44	88.0	4	8.0	36	72.0	14	28.0	43.85	0.001**

A statistically significant difference (P ≤ 0.05)

A highly statistically significant difference (P ≤ 0.001)

Table(3) reveals nurses' knowledge regarding pressure injuries before, immediately after and after one month of the bundle implementation. It was found that, there was a statistically significant difference before, immediately after and after one month of bundle implementation. Whereas, 92.0%, 92.0%, 92.0%, 92.0% and 92.0% of nurses had a correct answer about the function of skin, common skin problem, the definition of pressure injury, classification and

common sites of pressure injury compared to 64.0%, 70.0%, 66.0%, 64.0% and 76.0% of them after one month respectively. As regards the nurses' knowledge about pressure injuries prevention and factors contribute to pressure injuries development a highly statistically significant difference was found (X² 43.85 & 29.05 at P-value < 0.001) respectively after the bundle implementation.

Table (4) : Distribution of the Studied Nurses According to their Compliance with Risk Assessment and Skin Assessment Before, Immediately After and After one month of Bundle Implementation (N=50)

Compliance Items	Before (n=50)				Immediately after (n=50)				After one month (n=50)				X ²	P - value
	Comply		Not comply		Comply		Not comply		Comply		Not comply			
	No	%	No	%	No	%	No	%	No	%	No	%		
Risk assessment:														
a. ≥28 d of age complete Braden Q assessment on admission and daily	0	0.0	50	100.0	40	80.0	10	20.0	25	50.0	25	50.0	34.387	0.000
b. ≤28 d of age, treat as high risk and All NICU patients, treat as high risk	0	0.0	50	100.0	41	82.0	9	18.0	30	60.0	20	40.0	84.013	0.000
c. Documented the risk assessment scale scores.	0	0.0	50	100.0	40	80.0	10	20.0	25	50.0	25	50.0	45.883	0.000
Skin assessment:														
a. Perform skin assessment with 4 hours of ICU admission	0	0.0	50	100.0	42	84.0	8	16.0	28	56.0	22	44.0	17.280	0.000
b. Documented skin assessment within 4 hours of admission	0	0.0	50	100.0	42	84.0	8	16.0	25	50.0	25	50.0	6.576	0.001
c. Daily head-to-toe evaluation of entire body surface	0	0.0	50	100.0	38	76.0	12	24.0	28	56.0	22	44.0	90.378	0.000
d. Document specific body area of non-blanchable erythema or skin trauma due to pressure	0	0.0	50	100.0	38	76.0	12	24.0	30	60.0	20	40.0	11.098	0.001
e. perform physical examination (skin) on each turning /reposition manoeuvre	0	0.0	50	100.0	35	70.0	15	30.0	28	56.0	22	44.0	25.480	0.000
f. documented any loss of skin integrity	0	0.0	50	100.0	35	70.0	15	30.0	25	50.0	25	50.0	74.100	0.000
g. Reported any skin integrity loss to RN in charge	0	0.0	50	100.0	35	70.0	15	30.0	25	50.0	25	50.0	54.388	0.000

A statistically significant difference (P ≤ 0.05)

A highly statistically significant difference (P ≤ 0.001)

Table (4) shows nurses' compliance with risk assessment and skin assessment before, immediately after and after one month of bundle implementation. It was found that, there was a highly statistically significant improvement of nurses

compliance immediately after and after one month with most items of risk assessment and skin assessment (P < 0.000).

Table (5): Distribution of the Studied Nurses According to their Compliance with Moisture Management and Nutrition Before, Immediately After and After one month of Bundle Implementation (N=50)

Compliance Items	Before(n=50)				Immediately after(n=50)				After one month(n=50)				X ²	P - value
	Comply		Not comply		Comply		Not comply		Comply		Not comply			
	No	%	No	%	No	%	No	%	No	%	No	%		
Moisture Management:														
a. Check common moisture sites every 2-4hours	0	0.0	50	100.0	50	100.0	0	0.0	35	70.0	15	30.0	62.388	0.000
b. Use diaper with breathable outer cover	0	0.0	50	100.0	44	88.0	6	12.0	33	66.0	17	34.0	7.258	0.001
C. Remove moisture from under devices	8	16.0	42	84.0	46	92.0	4	8.0	34	68.0	16	32.0	25.490	0.000
d. Keep skin under casts, splints, braces and collars dry and clean	7	14.0	43	86.0	47	94.0	3	6.0	30	60.0	20	40.0	73.100	0.000
e. In a diaper area keep skin dry, clean and change diaper as soon as they are wet	7	14.0	43	86.0	48	96.0	2	4.0	38	76.0	12	24.0	53.358	0.000
f. Apply protective cream to create a moisture barrier	0	0.0	50	100.0	48	96.0	2	4.0	35	70.0	15	30.0	33.178	0.000
g. Avoid diaper with nonbreathable plastic backing	4	8.0	46	92.0	44	88.0	6	12.0	33	66.0	17	34.0	55.736	0.000
h. If possible neonates bathed once a day	10	20.0	40	80.0	46	92.0	4	8.0	37	74.0	13	26.0	46.506	0.000
Nutrition:														
a. Nutritional status assessment undertaken by the clinical nutritionist on admission	3	6.0	47	94.0	47	94.0	3	6.0	25	50.0	25	50.0	40.054	0.000

A statistically significant difference ($P \leq 0.05$)A highly statistically significant difference ($P \leq 0.001$)

Table (5) shows nurses' compliance with moisture management and nutrition before, immediately after and after one month of bundle implementation. It was found that, there was a highly statistically significant improvement

of nurses compliance immediately after and after one month with most items of moisture management and nutrition ($P < 0.000$).

Table (6): Distribution of the Studied Nurses According to their Compliance with Reposition and Medical Devices Care Before, Immediately After and After one month of Bundle Implementation(N=50)

Compliance Items	Before(n=50)				Immediately after(n=50)				After one month(n=50)				X ²	P - value
	Comply		Not comply		Comply		Not comply		Comply		Not comply			
	No	%	No	%	No	%	No	%	No	%	No	%		
Repositioning:														
a. On my shift, neonate turn every 2 hours	15	30.0	35	70.0	40	80.0	10	20.0	37	74.0	13	26.0	92.388	0.000
b. Neonates positioned in a full lateral turn	8	16.0	42	84.0	48	96.0	2	4.0	35	70.0	15	30.0	7.258	0.001
C. Support surface was used for neonates support during repositioning / turning	5	10.0	45	90.0	48	96.0	2	4.0	30	60.0	20	40.0	26.490	0.000
d. Neonates' position change according to turn clock	10	20.0	40	80.0	45	90.0	5	10.0	35	70.0	15	30.0	75.100	0.000
e. If clinically possible, maintain head of bed less than or equal 30 degree	6	12.0	44	88.0	48	96.0	2	4.0	38	76.0	12	24.0	56.358	0.000
f. Heel protectors utilized	4	8.0	46	92.0	49	98.0	1	2.0	34	68.0	16	32.0	24.50	0.000
g. If clinically possible neonate sat out of bed today	10	20.0	40	80.0	40	80.0	10	20.0	30	60.0	20	40.0	48.94	0.000
h. Evaluate need for special bed based on skin assessment	0	0.0	50	100.0	42	84.0	8	16.0	25	50.0	25	50.0	12.818	0.003
i. Use gel peds, pillows and/ or pressure reduction devices to cushion bony prominences	9	18.0	41	82.0	47	94.0	3	6.0	30	60.0	20	40.0	32.708	0.000
j. positioning regimes were documented	5	10.0	45	90.0	48	96.0	2	4.0	25	50.0	25	50.0	25.200	0.000
Medical Devices Care:														
a. Assess skin in contact with medical devices each shift	0	0.0	50	100.0	48	96.0	2	4.0	28	56.0	22	44.0	17.865	0.000
b. Exposed skin was protected using padding and dressing	7	14.0	43	86.0	49	98.0	1	2.0	33	66.0	17	34.0	80.825	0.000
c. Rotate pulse- ox probe at least	0	0.0	50	100.0	47	94.0	3	6.0	31	62.0	19	38.0	83.526	0.000

every 8 hours														
d. Document specific areas of nonblanchable erythema or skin trauma	3	6.0	47	94.0	45	90.0	5	10.0	25	50.0	25	50.0	79.500	0.000
e. Securement and repositioning of nasogastric tubes and endotracheal tube every 12 hours	0	0.0	50	100.0	49	98.0	1	2.0	22	44.0	28	56.0	88.028	0.001

A statistically significant difference ($P \leq 0.05$)

A highly statistically significant difference ($P \leq 0.001$)

Table (6) shows nurses' compliance with repositioning and medical devices care before, immediately after and after one month of bundle implementation. It was found that, there was a highly statistically significant improvement of nurses

compliance immediately after and after one month with most items of repositioning and medical devices care ($P < 0.000$).

Table (7): Distribution of the Studied Nurses' Total Knowledge and Total Compliance Levels Before, Immediately After and After one month of Bundle Implementation (N=50)

Topics	before n=50		Immediately after n=50		After one month n=50		X ²	P – value
	No	%	No	%	No	%		
Total knowledge level								
Good	3	6.0	46	92.0	34	68.0	78.533	0.001**
Average	5	10.0	4	8.0	16	32.0		
Poor	42	84.0	0	0.0	0	0.0		
Total Compliance level								
Satisfactory Compliance	2	4.0	47	94.0	35	70.0	43.049	0.001**
Unsatisfactory Compliance	48	96.0	3	6.0	15	30.0		

**A highly statistically significant difference ($P \leq 0.001$)

Table (7) reveals the studied nurses' total knowledge and total compliance Levels before, immediately after and after one month of bundle implementation. It is clear from this table that, before bundle implementation, the majority (84%, & 96.0%) of nurses have poor knowledge and unsatisfactory compliance respectively. While, 92.0% & 94.0% of nurses

have good knowledge and satisfactory compliance immediately after bundle implementation compared to 68.0% and 70.0% of them after one month respectively. The table also, reveals that, there was a highly statistically significant difference ($P \leq 0.001$).

Table (8): Comparison between Study and Control Groups Regarding Stages of Pressure Injury (N=60)

Modified Braden scale	Study group (n=30)						Control group (n=30)						X ²	P- value
	1 st week of admission		2 nd week of admission		Before discharge		1 st week of admission		2 nd week of admission		Before discharge			
	No	%	No	%	No	%	No	%	No	%	No	%		
No risk	23	76.7	25	83.3	27	90.0	10	33.3	8	26.7	7	23.3	4.345	0.033**
Mild	3	10.0	2	6.7	2	6.7	2	6.7	3	10.0	5	16.7		
Moderate	2	6.7	2	6.7	1	3.3	6	20.0	7	23.3	6	20.0		
High risk	2	6.6	1	3.3	0	0.0	12	40.0	12	40.0	12	40.0		

**A statistically significant difference ($P \leq 0.05$)

Table 8 demonstrates that approximately more than three quarters(76.7% & 83.3%) of the neonates in the study group were not at risk of pressure injury in the first week of admission and second follow-up weeks respectively;this was increased to 90.0% before discharge. On the other hand,

around (40%) of neonates in the control group were at high risk from the first week of admission till before discharge. there was a statistically significant difference between study and control groups regarding stages of pressure injury ($P \leq 0.05$).

Table (9): Correlation between Nurses knowledge, Compliance and their personal Characteristics After Bundle Implementation (N=50)

Items	Pearson correlation coefficient			
	Nurses(n=50)			
	Knowledge score		Compliance score	
	Pearson	Sig	Pearson	Sig
Knowledge score	1		.657	0.001**
compliance score	.657	0.001**	1	
Age (Years)	.518	0.001**	.668	0.001**
Years of experience	.689	0.001**	.566	0.001*
Level of education	.204	.155	.265	.352

** Correlation is significant at the 0.01 level (2-tailed).

Table (9) presents the correlation between nurses' knowledge, compliance and their personal characteristics after bundle implementation. It is noticed that, there was a positive correlation between nurses knowledge and their compliance after bundle implementation ($r=.657$, $P<0.001$). Regarding to correlation between nurses knowledge, compliance with their age and years of experience after

bundle implementation, there were a statistically significant correlation between them ($r=.518$, $r=.689$, $r=.668$, $r=.566$, $P<0.001$ respectively) Additionally, there were no a statistically significant correlation between nurses knowledge, compliance with their level of education ($r=.204$, $r=.265$, $p>0.05$ respectively).

Table (10): Agreement upon the Experience Gained from Bundle implementation among the Studied Nurses (N=50)

Statements	Strongly agree/ agree	
	No	%
1- I am more knowledgeable about pressure injury prevention today than I was before	34	68.0
2- I am more comfortable implementing preventive bundle guidelines now than I was before	32	64.0
3- I am more knowledgeable about pressure injury classifications now than I was before	27	54.0
4- I am more knowledgeable about pressure treatment now than I was before	33	66.0
5- I believe that the preventive bundle guidelines are helpful in preventing pressure injury	25	50.0
6- I would like to have preventive bundle guidelines in the Neonatal Intensive Care Unit	31	62.0

As for the study nurses' opinion about the experiences gained from their practice of preventive bundle guidelines, **Table (10)** illustrates that the highest agreement is upon feeling more knowledgeable about pressure injury prevention and treatment (68.0% & 66.0%) respectively, followed by feeling more comfortable implementing preventive bundle guidelines now than I was before as well as nurses want to have preventive bundle guidelines in neonatal intensive care unit (64.0 & 62.0%) respectively. On the other hand, more than half (54.0%) of the studied nurses were more knowledgeable about pressure injury classifications.

DISCUSSION

Pressure injuries represent one of the most important iatrogenic lesions in hospital settings, which is why it is necessary to implement effective measures to resolve them. All critically ill neonates in intensive care units (ICU) are at risk for pressure injury development due to their high acuity, physiological responses to critical illness, and subsequent length of stay in the ICU. So, it is important to implement strategies that prevent pressure injury development in critically ill neonates. Evidence reveals that pressure injury incidence can be reduced through the implementation of a PU prevention care bundle (Coyer et al., 2015)³⁰.

The term "care bundle approach" refers to a set of three to six treatment interventions targeted towards a specific procedure, symptom, or treatment and is more effective than simply following clinical guidelines. This may be due to the mandatory and audited nature of care bundles, whilst clinical guidelines are regarded as advisory. The main concept of the care bundle approach is to group the best evidence together, implemented at the same time, and then audited regularly such interventions can increase compliance and produce greater positive outcomes for neonates than when carried out individually (Robb et al., 2010)³¹.

Therefore, the aim of the present study was to evaluate the effectiveness of preventive bundle guidelines on reducing iatrogenic pressure injuries among critically ill neonates. This aim was achieved throughout the study findings and the research hypotheses were accepted.

As regards nurses' characteristics, the findings of the current study revealed that the highest percentage of studied nurses were female and having a diploma in nursing. These results were in the same line with Miyazaki et al., (2010)³², who conducted a study to assess knowledge on pressure ulcer prevention among nursing professionals and found that, the majority of studied nurses were female and having diploma

in nursing. From the researchers' point of view, a nursing job in Egypt was exclusive for females only till few years ago, thus the profession of nursing in Egypt was mostly feminine and the number of nurses graduated from diploma schools is higher than bachelor graduated nurses.

Researchers in this study believed that easy access of guidelines will help the nurses in the continuity of the professional role. In the present study, the majority of nurses reported that, there are no available preventive bundle guidelines for prevention of pressure injuries. This agrees with the results of **Ebi et al., (2017)**³³ who conducted a study to assess nurses' knowledge and perceived barriers about pressure ulcer prevention and reported that, there are no universal guidelines on prevention of pressure ulcers and this is seen as a barrier for carrying out pressure ulcer prevention measures.

Nonetheless, all nurses didn't attained any educational program toward prevention and management of neonatal pressure injuries. This result is consistent with **Habiballah, (2018)**³⁴ who carried out a study to assess attitudes of intensive care nurses towards pressure ulcer prevention and found that, around half of nurses had never received training on pressure ulcer prevention (48.2%). Similarly, This result in the same line with **Uba et al., (2015)**³⁵ who conducted a study to describe nurses' knowledge, attitude and practice regarding pressure ulcer prevention and found that, 71.7% of nurses did not receive training on pressure ulcer prevention. From the researchers' point of view, training is important for increasing the chance for nurses to up-date their knowledge and improving their compliance towards prevention of pressure injuries. Moreover, in-service training is essential to maintain the competency required to make better clinical decisions.

The finding of our study revealed that less than three-quarter of studied nurses had three to less than seven years of experience. According to **Ilesanmi et al., (2012)**³⁶ who conducted a study to assess nurses' knowledge of pressure ulcer prevention in Ogun state, Nigeria and mentioned that, years of experience for nurses had an important role in providing them experience to know how to prevent pressure injuries. From the researchers' point of view, years of experience in intensive care unit have a significant effect on nurses' knowledge and practices which result in improving nurses' compliance with the optimal performance in all nursing aspects of their field.

In an attempt to identify barriers to applying preventive bundle guidelines among nurses in the current study, nurses attributed to lack of up-to-date knowledge, high workload and insufficient equipment were the common barriers. These results are in congruence with **Al-Ghamdi, (2017)**³⁷ who conducted a study to assess factors affecting nurses' compliance in preventing pressure ulcer and found that, heavy workload/staff shortage is considered as the most barriers facing nurses' compliance regarding prevention pressure ulcer. Moreover, this finding is similar to **Mwebaza, et al., (2014)**³⁸ who assess nurses' knowledge, practices, and barriers in care of patients with pressure ulcers in a Ugandan teaching hospital and found that, shortage of supplies, resources and lack of training were the

most barriers to carrying out appropriate pressure ulcer management.

On assessing nurses' knowledge about pressure injuries, the findings of the current study reflected that, the total levels of nurses' knowledge before program implementation were poor. This may be due to lack of training program in this field, unavailability of preventive bundle guidelines, an absence of multidisciplinary team cooperation, and lack of nurses' incentives and desires to improve their knowledge especially who work in intensive care units for several years. This finding goes in line with **Al-Shidi, (2016)**³⁹ who conducted a study to explore the nurses' level of knowledge in relation to prevention and management of pressure ulcer in Oman and revealed that, nurses had a low level of knowledge regarding management and prevention of pressure ulcers. Similarly, **Mwebaza, et al., (2014)**³⁸ who revealed that, the majority of nurses had a poor level of knowledge regarding risk factors, and prevention of pressure ulcers. In addition, this finding is in agreement with **Abou El Enein & Zaghoul, (2011)**⁴⁰ who assess nurses' knowledge of prevention and management of pressure ulcer at a health insurance hospital in Alexandria and illustrated that, nurses had a poor level of knowledge regarding prevention and management of pressure ulcer.

However, after implementation of the program, there was a significant improvement in the total scores of nurses who achieve a good level of knowledge. This finding is matched with the hypothesis number one. The improvement scores indicated that, the bundle was a successful method to increase nurses' knowledge about pressure injuries. This finding on the same line with findings of **Hassan, (2018)**⁴¹ who conducted a study to evaluate the effectiveness of educational guidelines for pediatric nurses on the prevention of pressure injury among infants in intensive care unit and found that there was a significant improvement in nurses knowledge and the majority (92%) of them had a satisfactory level of knowledge after guidelines implementation. Additionally, this finding was identical with **Hashad & Hassan, (2018)**⁴² who conducted a study to evaluate the effect of implementing a designed skin care bundle protocol on modifying nurses' practices towards pediatric intensive care unit patients and revealed that high percentage (71.4%) of nurses' had a significant good sufficient knowledge about pressure ulcer and skin care bundle after program implementation.

Regarding nurses' Compliance with preventive bundle guidelines, there was a highly statistically significant improvement of nurses' compliance immediately after the bundle implementation. This finding matches with the hypothesis number two. From researchers' points of view, this improvement was significantly associated with more familiarity and understanding of the bundle guidelines. This finding is consistent with **Tayyib et al., (2016b)**²⁶ who conducted a study to appraise the implementation of a pressure ulcer prevention bundle in an adult intensive care and demonstrated a highly significant level of compliance among nurses after the pressure ulcer prevention bundle implementation (78.1%). Meanwhile, **Visscher et al., (2013)**²⁷ mentioned in their study about implementing a quality-improvement intervention to reduce pressure ulcer in

pediatric intensive care units that, nurses' compliance averaged 81% in the pediatric intensive care unit and 50% in the neonatal intensive care unit.

Nevertheless, the improvement of nurses' compliance in the present study decreased after one month. This drop of compliance might be due to inadequate equipment, lack of continuous training and feedback. At the same point of view, **Horner, (2012)**⁴³ supported that, more educational sessions and continuous training, evaluation and the provision of feedback to the nurses will increase understanding of the intervention and familiarity with the bundle, which in turn lead to an increased compliance to the intervention.

The present study showed that, preventive bundle guidelines were significantly reduced the pressure injuries among study group compared with the control group evidence by the majority of neonates in the study group were not at risk of pressure injury after bundle implementation. These findings support the hypothesis number four. From the researchers' point of view, this findings add more support for applying the prevention bundle guidelines to prevent iatrogenic pressure injury because they allow rapid spread of best practices among nurses result in improving their compliance and clinical outcomes. These findings are in harmony with a study carried out by **Frank et al., (2017)**⁴⁴ to describe change in pressure injury rate in pediatric hospitals after implementation of pressure injury prevention bundle and revealed that, there was a significant reduction of pressure injuries especially stage three and four after implementation of elements of prevention bundle. Additionally, **Tayyib et al., (2015)**⁴⁵ who carried out a study to determine the effectiveness of a pressure ulcer prevention bundle for critically ill patients and illustrated that, prevention bundle helps in reducing pressure injury in the intervention group 17.1% as compared with 52.8% in the control group. In this context, **Miller et al., (2010)**⁴⁶ showed an association between improved compliance with bundle elements and improved clinical outcomes.

As regard to the correlation between total knowledge of nurses and their personal characteristics, the current results revealed that there was a statistically significant positive correlation between total knowledge of nurses with their age, and years of experience after bundle implementation. These findings match with the hypothesis number three. This means that knowledge increases with age and years of experience. This result is congruent with **Al-Shidi, (2016)**³⁹ who found that, there was a significant relation between the total knowledge of nurses with their age, and years of experience.

As shown by the present study, there was a statistically significant positive correlation between total compliance of nurses with their age and years of experience after bundle implementation. This means that, nurses who have more age and experience are more likely to have more compliance score. This result contradicted with **Tayyib et al., (2015)**⁴⁵ who mentioned that, there were no a significant differences between nurses' demographic characteristics and their compliance scores.

Concerning the correlation between total nurses' knowledge and compliance score after use of bundle implementation. The present study illustrates that, there was a positive correlation between total nurses' knowledge and compliance scores after bundle implementation. This result is congruent with **Beeckman et al., (2011)**⁴⁷ who conducted a study to assess Knowledge and attitudes of nurses on pressure ulcer prevention: a cross-sectional multicenter study in Belgian hospitals and found that, nurses' knowledge is positively associated with evidence-based compliance.

As for the study nurses' opinion about the experiences gained from their practice of preventive bundle guidelines, the current finding illustrates that, the highest agreement is upon feeling more knowledgeable about pressure injury prevention and treatment followed by feeling more comfortable implementing preventive bundle guidelines, as well as nurses, want to have preventive bundle guidelines in neonatal intensive care unit. This finding is similar to **Konstantin, (2017)**²⁹ who conducted a study to evaluate the effectiveness of the unit-based skin care intervention in pediatric intensive care unit and found that, 67% of the nurses agreed they were more knowledgeable about pressure injury prevention methods, and 66% of them strongly agreed that a unit-specific skin-care-intervention would be beneficial in preventing pressure injuries. Finally, 55% of them agreed they felt more comfortable implementing skin care intervention.

CONCLUSION

Based on the results of the present study, it can be concluded that, the implementation of preventive bundle guidelines is a key element for the translation of intervention from evidence to the clinical settings, and proved to be effective in improving nurses' knowledge and their compliance, with a positive impact on the incidence of pressure injury among critically ill neonates. Moreover, there was a significant positive correlation between nurses' knowledge and compliance and their age and years of experience after bundle guidelines implementation.

RECOMMENDATION

In the light of the findings of the current research, the following recommendations are suggested:

1. Provide continuous education and training sessions for nurses about pressure injuries prevention by applying preventive bundle guidelines to improve their compliance.
2. Emphasis on the availability of printed bundle guidelines about pressure injury management and prevention that illustrated simply in posters for guiding nurses practice.
3. Preventive bundle guidelines should be implemented in all hospitals caring for children to reduce the harm associated with hospital-acquired pressure injuries.
4. Availability of all supplies and equipment required for applying preventive bundle guidelines.
5. Further study can be replicated on other hospitals using a large sample size to clinically verify the effectiveness of the care bundle and generalize the results of the study.

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