

## Nurses' Performance Regarding Non-Invasive Ventilation of Neonates and its Relation to Associated Pressure Injuries

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### Abstract

**Background:** Non-invasive ventilation is an effective way for providing respiratory support for neonates with respiratory insufficiency. It has significantly decreased the need for endotracheal intubation. However, non-invasive ventilation has been associated with pressure injuries. **Aim:** to assess nurses' performance regarding non-invasive ventilation of neonates and its relation to associated pressure injuries. **Design:** descriptive correlational research design. **Settings:** this study was conducted at Neonatal Intensive Care Units of El-Menshawey General Hospital, Kafrelsheikh General Hospital and Kafrelsheikh University Hospital. **Subjects:** All pediatric nurses (110) who are working at the previously mentioned settings and all neonates (110) received non-invasive ventilation at the time of data collection were involved in the study. **Tools of data collection:** three tools were used, Tool (I) non-invasive ventilation and pressure injuries questionnaire, Tool (II) nurses' assessment of hyperemia and Tool (III) nurses' practice observational checklists. **Results:** the current study revealed that less than three-quarters of the nurses had low level of knowledge and none of them had high level of knowledge. Nurses' practice regarding non-invasive ventilation and skin care was unsatisfactory. There was a highly statistically positive correlation between nurses' total knowledge and nurses' total practice related to non-invasive ventilation and skin care. **Conclusion:** the studied nurses had poor level of knowledge and unsatisfactory practice regarding non-invasive ventilation and skin care. **Recommendations:** educational program and periodic workshops regarding non-invasive ventilation and neonatal skin care should be provided for nurses working at NICU.

**Keywords:** Nurses' performance, Non-Invasive Ventilation, Neonates, Pressure Injuries

### Introduction

The neonatal period is the first four weeks of infant's life. During this time, the neonate undergoes marked physiological changes that occur in all organ systems especially regarding the respiratory and cardiovascular systems. These changes occur due to transition from fetal circulation to neonatal or postnatal circulation (Rey y., et al., 2022).

Respiratory support is very important care in the Neonatal Intensive Care Unit (NICU). Both non-invasive modalities and invasive mechanical ventilation may be used for neonates with respiratory problems as respiratory distress syndrome, meconium aspiration and apnea (Said & Mohamed, 2019 and Anne & Murki, 2021).

Nevertheless, non-invasive ventilation use is associated with development of pressure injuries, which is a serious side effect. Pressure injuries develop on bony prominence regions due to contact pressure between the interface and the neonates' skin (**Behnke et al., 2019**). Because the skin of new born is immature and fragile it increases the risk of developing a pressure injury. Fifty percent of pressure ulcers in neonates were reported to be associated with the use of medical equipment and devices (**Kathy, 2019**).

Pressure injuries is a localized injury to the skin and underlying tissue as a result of pressure from a device as nasal cannulas, tubing, prongs and oxygen face masks (**Stellar & Curley, 2020 and García & Verdú, 2018**). Nasal and facial injuries are most common injuries in neonates receiving non-invasive ventilation due to improper fixation and position of nasal interface, incorrect size of mask and over-tightening of the head strap (**Naha N., et al., 2019**).

#### **Significance of the study**

Respiratory distress is a main health problem occurred in the newborn stage. In Egypt, 46.5% of neonates admitted to NICU had respiratory distress (**Baseer et al., 2020**). Over the past two decades, there has been an evident increase in the use of non-invasive ventilation. Now it becomes an integral tool in the management of both acute and chronic respiratory problems (**Lee et al., 2020**). However, one of the major problems associated with using NIV in NICU is the occurrence of facial or nasal mucosal injuries. The incidence of nasal injury resulting from NIV in previous studies was 37.16% in the first stage, and 63.64% in the second stage (**Biazus et al., 2023 and Ribeiro et al., 2021**). So, Neonates require

special care at neonatal intensive care units provided by highly qualified nurses to enhance their health and decrease mortality rate (**Elsobkey, 2018**).

#### **Aim of the study**

The current study was aimed to assess nurses' performance regarding non-invasive ventilation of neonates and its relation to associated pressure injuries.

#### **Research Questions**

- **Q1:** What is the level of nurses' performance regarding non-invasive ventilation of neonates?
- **Q2:** What is the relation between non-invasive ventilation and associated pressure injuries of neonates?

#### **Subjects and Method**

##### **Research design**

A descriptive correlational research design was in the current study.

##### **Research settings**

The study was conducted at Neonatal Intensive Care Units of El-Menshawey General Hospital & Kafrelsheikh General hospital which are affiliated to the Ministry of Health & Population and kafrelsheikh university hospital which affiliated to the Ministry of Higher Education and Research

#### **Subjects and Method**

##### **Research design**

A descriptive correlational research design was in the current study.

##### **Research Subjects**

- All pediatric nurses (110) who are working at the previously mentioned settings. They were classified as, 45 nurses from El-Menshawey General Hospital, 35 nurses from Kafrelsheikh General Hospital, and 30 nurses from Kafrelsheikh University Hospital.
- All neonates (110) regardless their gestational age, weight & diagnosis who

received non-invasive ventilation at the time of data collection were involved in the current study.

### **Tools of Data Collection**

Three tools were used for data collection.

#### **Tool (I): Non-invasive ventilation and pressure injuries questionnaire.**

A structured interview schedule was used to assess nurses' knowledge about non-invasive ventilation of the neonates and associated pressure injuries. It consisted of four parts as follow:

##### **Part (1): Socio-demographic characteristics of the studied nurses**

This part was developed by the researcher to collect data about nurses' age, sex, educational level, marital status, years of experience at NICU and previous training program.

**Part (2): Bio-socio demographic characteristics of neonates:** It was developed by the researcher to collect data about neonates' current age, gestational age at birth, birth weight, medical diagnosis, length of hospital stay, duration of non-invasive ventilation and type of interface.

**Part (3): Nurses' knowledge regarding non-invasive ventilation:** This part was developed after reviewing recent related literatures (August., et al 2018 and Irtanti., et al 2019). It included definition, indications, types, interfaces, size of prongs, side effects and complications of non-invasive ventilation and weaning from NIV.

##### **Part (4): Nurses' knowledge about Pressure Injuries**

This part was developed after reviewing recent related literatures (Mohamed et al. 2019, Nasreen et al. 2018 & Hameed Helal et al. 2022). It included definition, degrees, manifestations, predisposing factors

complication and prevention of pressure injuries.

The questionnaire sheet was consisted of 25 questions; each question was scored from 0-2 grades. The correct and complete answer was scored 2, correct and incomplete answer was scored 1, and incorrect answer or don't know was scored 0. The sum of all questions was 50.

#### **Total score of nurses' knowledge was calculated as following**

- A score of  $\geq 80\%$  was considered high level of knowledge.
- A score between  $60\%$  to  $\leq 80\%$  was considered moderate level.
- A score below  $60\%$  was considered low level of knowledge.

#### **Tool (II): Assessment of hyperemia/ Nasal Skin Injuries**

It was developed by National Pressure Ulcer Advisory Panel (2016) and was adapted by the researcher and used to assess nasal skin injuries. Nurses used assessment of hyperemia to classify neonates as follow:

- **Stage (1):** Assessment of superficial ulceration including assessment of intact skin with non-blanchable erythema.
- **Stage(2):** Assessment of necrosis: partial loss of dermis thickness, presenting as a superficial wound, red bed, no crust.
- **Stage (3):** Total nasal tissue loss: necrosis and total tissue loss.

#### **Tool (III): Nurses' Practice Observational Checklists**

It was consisted of two parts, and was used by the researcher to assess nurses' practice regarding non-invasive ventilation.

##### **Part (1): Nursing practice regarding non-invasive ventilation.**

It was developed by the researcher after reviewing the recent related literatures (Chen et al., 2018 and Abd El Aziz et al. 2022 and

**Elsobkey., et al 2018).** It was used to assess nurses' practice regarding non-invasive ventilation. It included hand washing (14 items), preparation of equipment (15 items), fixation of interface and nasal prongs (16 items), position of neonate (5 items), suction (28 items), delivery of humidified oxygen (5 items).

### **Part (2): Nursing practice regarding skin care**

It was adapted from (**Goldstein., 2019 and Said et al. 2019**) to assess nurses' practice regarding skin care. It included several steps such as physical examination of facial and nasal skin (9 items) , routine skin and nose care (12 items) .

Scoring system for nurses' practice by using observational checklist which consisted of (104 items); each item was scored from (0-1). Done correct and complete was scored (1), while done incorrect or didn't do well was scored (0)..

### **Total score for nurses' practice was calculated and classified as follow:**

- Nurses were considered satisfactory if their practice scores  $\geq 80\%$ .
- Nurses were considered unsatisfactory if their practice scores  $< 80\%$ .

## **Method**

### **1. Administrative process**

An official permission for data collection was obtained from the Dean of the Faculty of Nursing, Tanta University and was directed to administrators responsible for Neonatal Intensive Care Units of El-Menshawy General Hospital, Kafrelsheikh General Hospital and Kafrelsheikh University Hospital to obtain their approval and cooperation to carry out this study after explaining the aim of the study.

### **2. Ethical and legal considerations**

- a. Ethical approval to conduct the study was taken from scientific research ethical committee at the Faculty of Nursing, Tanta University code no 109/10/2022.
- b. Consent of nurses was obtained after explaining the aim and nature of the study.
- c. Privacy and confidentiality was maintained regarding data collection.
- d. Nature of the study was not causing any harm or pain to the entire sample.
- e. All nurses were informed about the purpose, tools and duration of the study after explaining the benefits of the study. During the study the researcher informed the nurses about their right to withdraw at any time they want without any reason.

### **3. Content validity**

The tools of the study were presented to a jury of five experts in the field of Pediatric Nursing to check content validity and clarity of the questionnaire. Modifications were carried out accordingly. Content validity index = 98.5%.

### **4. Content Reliability**

- The study tools were tested by the pilot subjects. The test of reliability (cronbach's alpha) was 0.816 for knowledge Tool (I), 0.850 for Tool (II) and 0.975 for practice Tool (III) that indicates high reliability of the tools used for data collection in the current study.

### **5. Pilot study**

A pilot study was carried out on eleven nurses (10%) to test the feasibility and clarity of tools accordingly the necessary modifications was done. Pilot study was excluded from the study because of the modification done on the study tools.

### **6. Actual phase of the study**

It was carried out by the researcher for all study subjects to collect baseline data, assess

nurses' knowledge and practice regarding non-invasive ventilation and associated pressure injuries of neonates.

The nurses were selected from both previous mention setting. Formal consent was obtained from nurses for participation in the study after explaining the aim of the study. The studied subjects were reassured that all information was confidential and used only for the purpose of the study.

The researcher assessed the socio-demographic data of the studied nurses and neonates receiving non-invasive ventilation. Also, nurses' knowledge regarding non-invasive ventilation and associated pressure injuries of neonates by using questionnaire sheet. The questionnaire was distributed to nurses to obtain the needed data using tool (I). It takes about 20 minutes to fulfill this part of data collection. Tool (II) was used to obtain data about nurses' assessment the stages of hyperemia and nasal skin injuries.

The researcher observed the nurses (two nurses per day) during their performance of routine care for neonate's receiving non-invasive ventilation as hand washing, preparation of equipment, fixation of interface and nasal prongs. Nurses also, were observed during positioning of neonate, doing suction, delivery of humidified oxygen, physical examination of facial and nasal skin. They also, assessed during their performance of routine skin and nose care. The researcher was available at the study settings 3 days per week in the mooring and evening shifts.

The researcher started to collect necessary data firstly from Kafrelsheikh University Hospital from beginning of March 2023 to the end of May then from El-Menshawey General Hospital from beginning of June to the end of July and finally collected from

Kafrelsheikh General Hospital from beginning of August to the end of September 2023. The data were collected over a period of 6 months starting from March 2023 to September 2023.

#### **Statistical analysis of the data**

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. Qualitative data were described using number and percent. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level. For categorical variables, to compare between different categories was done using Chi-square test ( $\chi^2$ ). Correction for chi-square when more than 20% of the cells have expected count less than 5 was done by using Fisher's Exact or Monte Carlo correction. For abnormally distributed quantitative variables, to compare between two studied groups Mann Whitney test was used. To correlate between two normally distributed quantitative variables was calculated. To correlate between two normally distributed quantitative variables Pearson coefficient was calculated.

#### **Results**

**Table (1):** Shows percentage distribution of the studied nurses according to their socio-demographic characteristics. It was observed that about 41.9% of the studied nurses were aged from 25 to 35 years with mean  $\pm$  SD was  $29.12 \pm 5.98$  years. Most of the studied nurses (88.2%) were females. Slightly, more than half of the nurses (55.6%) were single. It was found that 52.7% of the nurses had bachelor of nursing. Concerning their years of experience, it was observed that 41.8% of the nurses had one to less than three years of

experience with mean years of experience  $4.39 \pm 3.25$  years.

**Table (2):** illustrates percentage distribution of studied neonates according to their bio-socio-demographic characteristics. It was revealed that the mean age of the studied neonates was  $13.01 \pm 8.94$  days. In addition, nearly two thirds of the neonates (60 %) were male. Furthermore, most of the studied neonates (81.8 %) had a gestational age less than 37 weeks and 35.5 % of them had a birth weight less than 2500g.

**Figure (1):** shows percentage distribution of the studied nurses according to attendance of previous training program. It was found that, less than three quarters of nurses (72.7%) hadn't attended any training program about NIV and associated pressure injuries. While only 27.3% of them reported that they already attended training program about NIV.

**Figure (2):** shows percentage distribution of the studied neonates according to medical diagnosis. It was obvious that, more than two thirds of them (67.3%) had respiratory distress syndrome and nearly equal percentage (17.3% and 15.5%) had aspiration pneumonia and transient tachypnea of newborn respectively.

**Figure (3),** It was found that 60% of the studied neonates were on CPAP Hudson prongs and 23.6% of them on CPAP N flow prongs while, 16.4% were on High-flow nasal cannula.

**Figure (4):** This figure shows distribution of the studied neonates according to the presence of pressure injuries. It was found that nearly three quarters of the neonates (73.6%) had signs of pressure injuries and 26.4% hadn't pressure injuries at the time of data collection.

**Table (3):** illustrates nurses' total levels of knowledge about non- invasive ventilation and pressure injuries. It was evident that less than three- quarters of the nurses (70.9%) had low level of knowledge, 29.1% had moderate level and none of the nurses total knowledge was in the high level.

**Table (4):** shows percentage distribution of the studied nurses according to assessment of stages of hyperemia and nasal skin injuries. It was found that slightly more than half of the nurses (57.3%) correctly performed assessment of superficial ulceration and 78.2% incorrectly assessed skin with non-blanch able erythema.. Moreover, more than two-thirds of the studied nurses (67.3%) incorrectly performed assessment of hyperemia stages compared to nearly one - third of them (32.7%) didn't perform it correctly.

**Figure (5):** shows the percentage distribution of total nurses' level of practices regarding non- invasive ventilation and skin care of the studied nurses. It was obvious that about two thirds of the nurses (61.8%) had unsatisfactory level of practice and about one third (38.2%) had satisfactory level of practice.

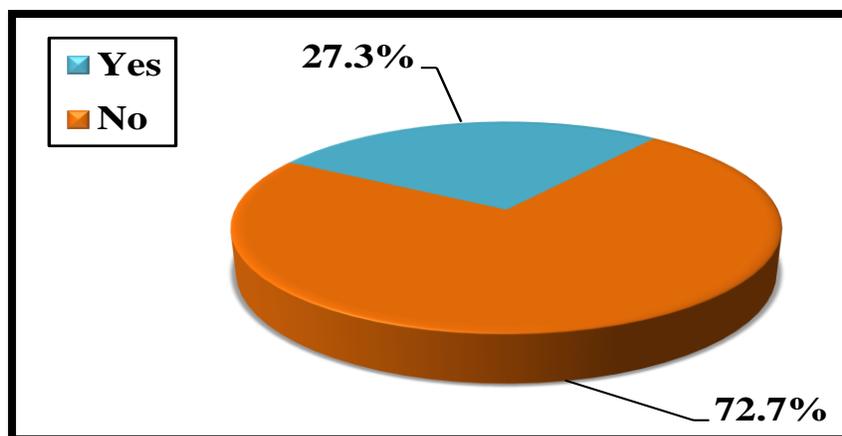
**Table (5):** illustrates correlation between total nurses' knowledge and total practice. It was cleared that there were highly significant correlations which were positive between total nurses' practice regarding non-invasive ventilation and nurses' total knowledge regarding both non-invasive ventilation and pressure injuries ( $P = <0.001^{**}$ ). As well, it was evident there were a highly statistical correlations were found between nurses' total practice and nurses' total knowledge ( $P = <0.001^{**}$ ).

**Table (6):** presents relation between bio-socio demographic characteristics of

neonates and the presence of pressure injures associated with NIV. It was found that there was highly significant difference between neonates mean age and presence of pressure injures. ( $p = <0.001^{**}$ ). As well, it was noticed that there were highly statistical significant relations between the neonates birth weight, medical diagnosis, length of hospital stay, duration of non- invasive ventilation and type of interface with pressure injures occurrence ( $p = <0.001^{**}$ ).

**Table (1): Distribution of the studied nurses according to socio-demographic data (n = 110)**

<b>Socio-demographic data of nurses</b>	<b>No.</b>	<b>%</b>
<b>Age (years)</b>		
– 20 – < 25	25	22.7
– 25 – <30	46	41.9
– 30 – <35	25	22.7
– ≥40 year	14	12.7
– Mean ± SD.	29.12 ± 5.98	
<b>Sex</b>		
– Male	13	11.8
– Female	97	88.2
<b>Marital status</b>		
– Single	61	55.5
– Married	48	43.6
– Divorced	1	0.9
– Widow	0	0.0
<b>Educational level</b>		
– Secondary school of nursing	0	0.0
– Technical institute of nursing	34	30.9
– Bachelor of nursing	58	52.7
– Post graduate	18	16.4
<b>Years of experience at NICUs</b>		
– 1 - < 3	46	41.8
– 4 - < 6	39	35.5
– 7 - < 10	12	10.9
– More than 10 years	13	11.8
– Mean ± SD.	4.39 ± 3.25	



**Figure (1):** Distribution of the studied nurses according to attendance of previous training program about non-invasive ventilation and associated pressure injuries (n = 110)

**Table (2):** Distribution of the studied neonates according to bio-socio demographic characteristics of neonates (n = 110)

Bio-socio demographic characteristics of neonates	No.	%
<b>Current age in days</b> – (Mean ± SD.)	13.01 ± 8.94	
<b>Sex</b>		
– Male	66	60.0
– Female	44	40.0
<b>Gestational age at birth</b>		
– ≤37 weeks	90	81.8
– 38-42weeks	15	13.6
– More than 42 weeks	5	4.6
<b>Birth weight</b>		
– 2700g-<4000 g	21	19.0
– <2500	39	35.5
– <1500g	22	20.0
– <1000g	28	25.5
<b>Length of hospital stays (Days) (Mean ± SD.)</b>	13.01 ± 8.94	
<b>Duration of non- invasive ventilation (Days)</b> – Mean ± SD	9.31 ± 6.45	

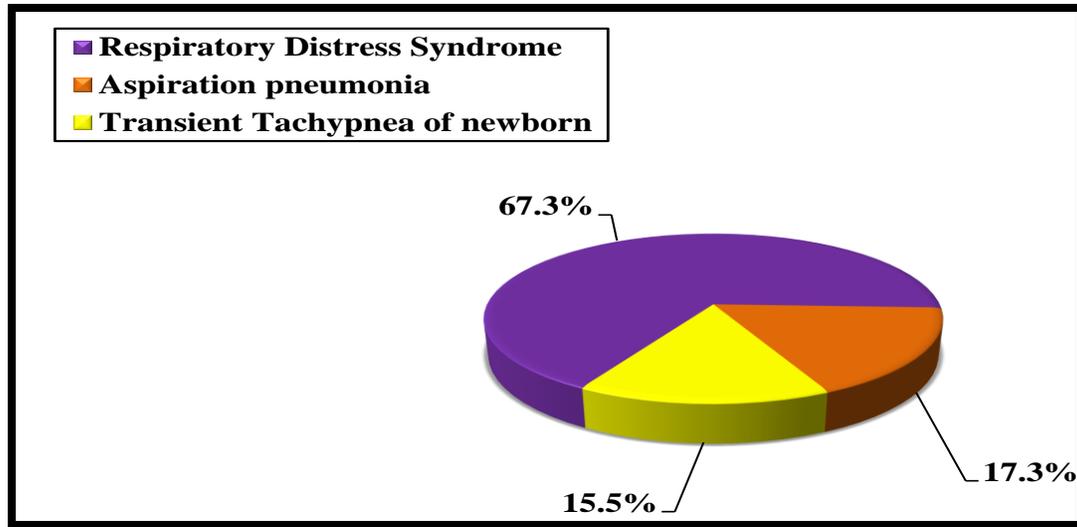


Figure (2): Distribution of the studied neonates according to medical diagnosis (n = 110)

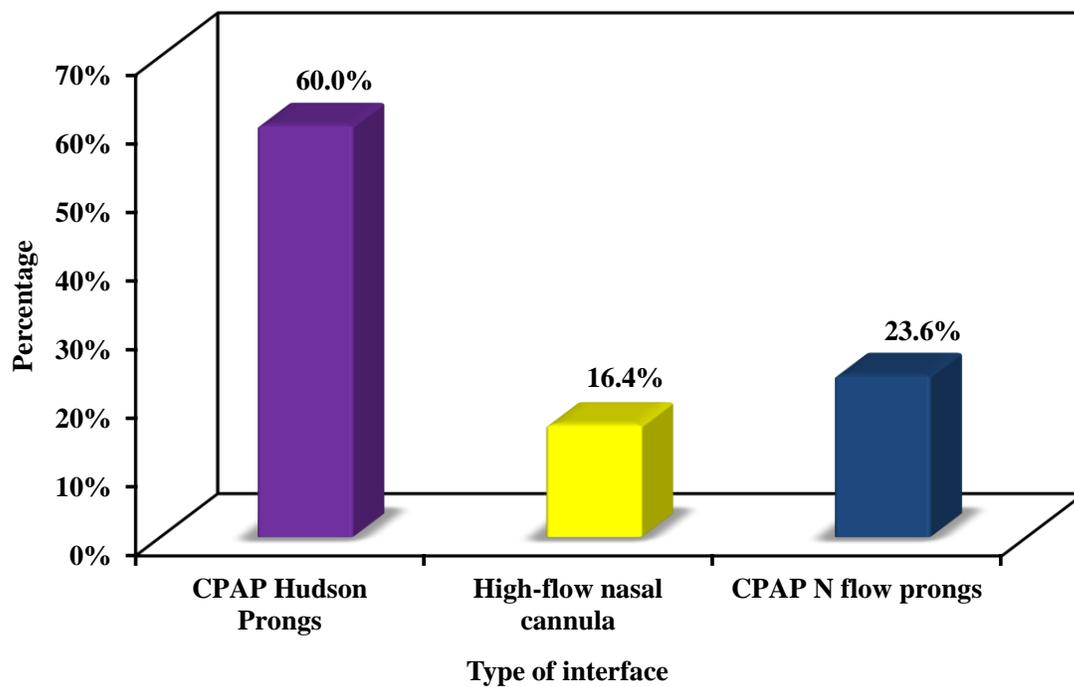
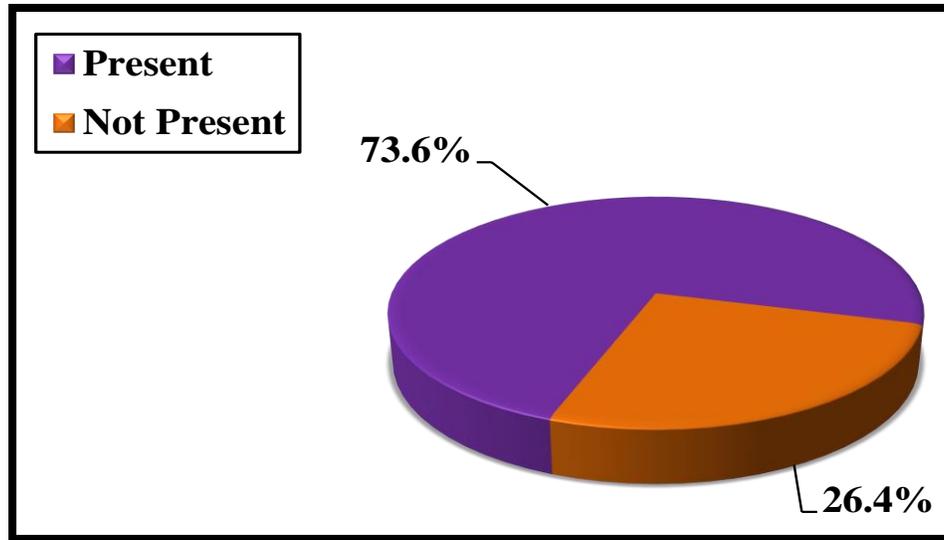


Figure (3): Distribution of the studied neonates according to Type of interface of neonates (n = 110)



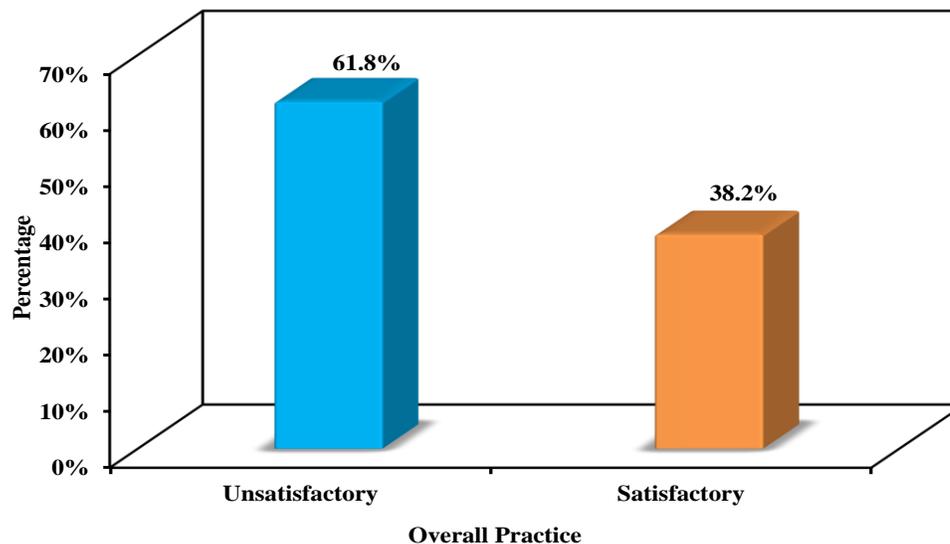
**Figure (4):** Distribution of the studied neonates according to presence of pressure injuries (n = 110)

**Table (3):** Distribution of the studied nurses according to total levels of knowledge about non- invasive ventilation and pressure injuries (n = 110)

Nurses' knowledge	Low (<60%)		Moderate (60 - 80%)		High (>80%)	
	No.	%	No.	%	No.	%
Non-invasive ventilation (NIV)	90	81.8	20	18.2	0	0.0
Pressure Injuries	61	55.5	35	31.8	14	12.7
Total knowledge	78	70.9	32	29.1	0	0.0

**Table (4): Distribution of the studied nurses according to their assessment of stages of hyperemia and nasal skin injuries (n = 110)**

Stage of hyperemia and nasal skin injuries	Incorrectly done\ Not done		Done correctly	
	No.	%	No.	%
<b>Stage (1)</b>				
Assessment of superficial ulceration	47	42.7	63	57.3
Assessment of intact skin with non-blanch able erythema	86	78.2	24	21.8
<b>Stage (2)</b>				
Assessment of necrosis: partial loss of dermis thickness	84	76.4	26	23.6
Assessment of presenting as a superficial wound, red bed, no crust	80	72.7	30	27.3
<b>Stage (3)</b>				
Assessment of total nasal tissue loss and necrosis	73	66.4	37	33.6
<b>Total nurses assessment of hyperemia and nasal skin injuries</b>	<b>74</b>	<b>67.3</b>	<b>36</b>	<b>32.7</b>

**Figure (5): Nurses total practice of non- invasive ventilation and skin care (n = 110)**

**Table (5): Correlation between nurses' knowledge and nurses' practice  
(n = 110)**

Nurses' Practice	Nurses' knowledge					
	Non-invasive ventilation		Pressure Injuries		Total	
	r	p	r	p	r	p
Hand washing	0.371	<0.001**	0.296	0.002*	0.406	<0.001**
Preparation of equipment	0.204	0.032*	0.138	0.151	0.207	0.030*
Fixation of interface and nasal prongs	0.207	0.030*	0.220	0.021*	0.262	0.006*
Position of neonate	0.144	0.132	0.289	0.002*	0.270	0.004*
Suction	0.225	0.018*	0.399	<0.001**	0.387	<0.001**
Suction implementation	0.407	<0.001**	0.127	0.186	0.318	0.001**
Delivery of humidified oxygen	0.070	0.467	0.027	0.781	0.058	0.547
Total nurses' practice regarding non-invasive ventilation	0.452	<0.001**	0.451	<0.001**	0.553	<0.001**
Physical examination of facial and nasal skin	-0.016	0.864	0.181	0.058*	0.107	0.266
Routine Skin & nose care	0.061	0.526	0.031	0.751	0.055	0.567
Total nurses' practice regarding skin care	0.037	0.702	0.110	0.254	0.092	0.339
<b>Total Practice</b>	<b>0.383</b>	<b>&lt;0.001**</b>	<b>0.417</b>	<b>&lt;0.001**</b>	<b>0.490</b>	<b>&lt;0.001**</b>

\* Statistically significant at  $p \leq 0.05$

\*\* Highly statistically significant at  $p < 0.001$

**Table (6): Relation between neonatal bio-socio demographic characteristics and the presence of pressure injures associated with non-invasive ventilation**

Bio-socio demographic characteristics of neonates	Total neonate with pressure injures				Test of Sig.	p
	Present (n = 81)		Not Present (n = 29)			
	No.	%	No.	%		
Neonates mean age in days Mean ± SD.	15.95 ± 8.22		4.79 ± 4.77		U= 212.500*	<0.001*
Sex						
– Male	48	72.7	18	27.3	$\chi^2=$ 0.070	0.791
– Female	33	75.0	11	25.0		
Gestational age at birth					$\chi^2=$ 0.821	MCp= 0.744
– ≤37 weeks	67	74.4	23	25.6		
– 38-42weeks	11	73.3	4	26.7		
– More than 42 weeks	3	60.0	2	40.0		
Birth weight					$\chi^2=$ 21.438*	<0.001*
– 2700g-<4000 g	14	66.7	7	33.3		
– <2500	20	51.3	19	48.7		
– <1500g	20	90.9	2	9.1		
– <1000g	27	96.4	1	3.6		
Medical diagnosis					$\chi^2=$ 21.052*	MCp= <0.001*
– Respiratory Distress Syndrome	62	83.8	12	16.2		
– Aspiration	14	73.7	5	26.3		
– Transient Tachypnea	5	29.4	12	70.6		
Length of hospital stay (Days) Mean ± SD	15.95 ± 8.22		4.79 ± 4.77		U= 212.500*	<0.001*
Duration of non- invasive ventilation (Days) Mean ± SD	11.63 ± 5.97		2.83 ± 1.17		U= 34.500*	<0.001*
Type of interface					$\chi^2=$ 37.038*	<0.001*
- CPAP Hudson prongs	54	81.8	12	18.2		
- High-flow nasal cannula	3	16.7	15	83.3		
- CPAP N flow prongs	24	92.3	2	7.7		

\* Statistically significant at  $p \leq 0.05$ \*\* Highly statistically significant at  $p < 0.001$ .

## Discussion

Neonatal period is a very critical period in the newborns' life. Many transitional changes, particularly in the respiratory system. Non-invasive ventilation (NIV) has progressively become the preferred method of respiratory support for neonates with respiratory insufficiency. The skin of the neonate is very fragile, which makes it susceptible to pressure injuries. So, Neonates on non-invasive ventilation need special assessment and close monitoring for any signs of pressure injuries by health care providers especially the nurse.

The present study illustrated that more than half of the studied nurses had a bachelor degree in nursing and nearly one third was graduated from technical institute of nursing. From researcher point of view, the new trends of hospital are hiring high qualified nurses for critical areas like NICU. A study of **Khalil et al., (2021)** were compatible with the present study results as they assessed nurses' knowledge and practice regarding developmental supportive care for preterm and low birth weight infants and found that over the half of the nurses had bachelor degree. Another study by **Mansour et al., (2019)** was not matched with the current finding. They assessed nurses' knowledge and practices related to neonatal sepsis in NICUs at El-Minia Hospitals & found that only one quarter of nurses had bachelor degree.

Regarding the presence of pressure injuries the current study findings revealed that nearly three quarters of the neonates have pressure injuries and nearly half of them were in stage one and nearly one third of them in stage two. From researcher point of view, it may be due to the immaturity of their integumentary systems. Because of the

majority of the studied neonates was preterm and low birth weight they are more likely to sustain skin injuries from compression. A study conducted by **Dai et al., (2020)** was agreed with current findings. They conducted a study about nasal pressure injuries due to nasal continuous positive airway pressure treatment in newborns and encountered that stage one of nasal pressure injuries were observed in the majority of studied neonates. Another study by **Naha et al., (2019)** who assessed nasal injury with continuous positive airway pressure and need for privileging nursing staff was contradicted with the current study as they found that nearly half of the neonates had stages two pressure injuries.

Regarding the total scores of nurses' knowledge about non-invasive ventilation, the present study's finding illustrates that less than three-quarters of the nurses had low level of knowledge. This finding may be due to nearly three quarters of studied nurses didn't previously receive any training program about NIV. A study conducted by **Elsobkey et al., (2018)** was compatible with the present study results. They evaluated the effect of educational guidelines program about nursing care of neonates receiving continuous positive airway pressure and found that the majority of nurses in their study had poor knowledge about CPAP.

**Dake, (2020)** who assessed the effectiveness of training module regarding care of neonate on bubble CPAP on knowledge and practices of nurses working in neonatal intensive care unit was not matched with current study results. He found that that three-quarters of the nurses had an average level of knowledge about bubble CPAP. **Irtanti C., & Soetadji, T.(2019)** who carried out a study about knowledge the use of continuous positive

airway pressure in neonates was also disagrees with the current results and found that nearly three-quarters of the nurses had good level of knowledge about continuous positive airway pressure.

The current study showed that only few percentages of nurses had high level of knowledge regarding the total scores of nurses' knowledge about pressure injuries. This result due to lack of educational program about pressure injuries associated with non- invasive ventilation and hiring a fresh graduated nurses at NICU. A study by **Zakzouk et al. (2023)** which entitled " Effect of Educational program on Nurses' Performance Regarding Acquired Skin injuries at Neonatal Intensive Care Units" was agreed with the current study finding as they found that few percentage of the nurses had high level of knowledge regarding skin injuries in neonatal intensive care units.

The finding of the present study revealed that more than two-thirds of the studied nurses incorrectly assessed stages of hyperemia and skin injuries. This may be due to lack of nurses' experience regarding assessment of skin injuries. **Alshahrani et al., (2023)** who conducted a pre and post intervention study in the Kingdom of Saudi Arabia (KSA) to investigate nurses' knowledge and attitudes towards pressure injuries prevention was consistent with the current study as they found that nearly half of the nurses were able to classify pressure injuries.

The findings of the present study illustrated that the total scores of practice regarding non-invasive ventilation and skin care were unsatisfactory. From researcher point of view, this result can be due to lack of head nurse's follow up about nursing care provided to neonates on non- invasive ventilation and lack of nursing knowledge about non-

invasive ventilation. A study by **Soliman, (2023)** was agreed with current findings. They conducted a study about nurses' performance regarding care of preterm neonates with continuous positive airway pressure and reported that the majority of the nurses had incompetent levels of practice regarding continuous positive airway pressure ventilation.

Another study conducted by **Said et al., (2019)** was matched with current study results as they found that most of the nurses had incompetent practices regarding care for nasal skin for neonates undergoing nasal CPAP. **Another study by Milligan, (2019)** was supported the current findings and revealed that the total nurses' practice were unsatisfactory.

It was obvious that there was a highly statistical significant positive correlation between the studied nurses' total knowledge and their practices score regarding non-invasive ventilation and associated pressure injures. This may indicate that nurses' knowledge affected their practice and lack of knowledge may have an effect on nurses' performance. **Atwa et al., (2018)** who conducted a study in Pediatric Intensive Care Unit at Mansoura university to evaluate nurses' knowledge and practice towards high frequency oscillator ventilation was in harmony with present study result and revealed that there was a positive correlation between knowledge and practice of the studied nurses regarding high frequency oscillatory ventilation. Another study conducted by **Mohammed et al., (2023)** to assess nurses' knowledge and practices regarding care of high-risk neonates connected with mechanical ventilator was differed from the current study as thy reported that there was no statistically

significant correlation between the knowledge and practice of nurses.

The present study was proved that neonates birth weight, medical diagnosis, length of hospital stay, duration of non- invasive ventilation and type of interface had highly significant relation with occurrence of pressure injures. This result can be explained by prematurity is associated with low birth weight and it is the main cause of respiratory distress and increase susceptibility to skin injuries. **Imbulana et al., (2018) & Chen et al., (2020)** was consistent with the current study as he discovered that preterm neonates with low birth weights are more likely to develop pressure injuries.

### Conclusion

**Based on the current study findings, it was concluded that:**

The studied nurses had poor level of knowledge related to non-invasive ventilation and associated pressure injuries. Nurses' practices regarding non-invasive ventilation and skin care were unsatisfactory. Furthermore, there was a highly statistically positive correlation between nurses' total level of knowledge and their total practice regarding non-invasive ventilation and skin care of the neonates at the NICUs. There were statistical significant relations between neonates' birth weight, length of stay at NICU, duration of non- invasive ventilation and occurrence of pressure injures.

### Recommendations

In light of the current study's findings, the following recommendations can be suggested:

1- Educational programs and periodic workshops regarding non-invasive ventilation and neonatal skin care should be provided for nurses working at NICUs.

2- Non-invasive ventilation and pressure injuries prevention should be involved in the curriculum of nursing student.

3- Further studies should be conducted to updates nurses knowledge and practice regarding non-invasive ventilation.

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