Effect of Non-invasive Respiratory Support Care Bundle on Preterm Infants' Nasal Injury and Pain Response

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Abstract:

Background: The respiratory support devices can save the lives of preterm and full term neonates with respiratory insufficiency. Wide and early usage of non-invasive respiratory supports (NIRS) has significantly reduced the necessity for endotracheal intubation, on the other hand, NIRS has been linked to nasal damage. The **aim** of the study was to examine the effect of implement non-invasive respiratory support care bundle on preterm infants' nasal injury and pain response. **Method**: **Design**: A quasi experimental research design was utilized (Study-control). Setting: The study was carried out in the level (II) of neonatal intensive care unit (NICU) at Al-Nasr Specialized Hospital for Children in cooperation with Cleopatra Hospitals Group and El Salam Port Said Hospital in cooperation with El Salam International Hospital, Port Said Governorate, Egypt. Sample: It composed of 98 preterm infants. **Tools**: -I: Structured Questionnaire that includes; characteristics of preterm infants and clinical data of preterm infants. II: Nasal injury Likert Scale, III: Preterm Infant Pain Profile (PIPP) Likert Scale. **Results**; approximately one third (26.5%) of preterm infants in study group have no nasal injury post intervention compared with minority (10.2%) of preterm infants in control group with statistical difference (p 0.048). Also, none of preterm infants in study group have severe nasal injury compared with minority(8.2%) of preterm infant in control group, with highly statistical difference between both groups ($p<0.001$). More than one third (34.7%) of the study group's preterm infants have no – minimal pain level post intervention compared with minority (14.3%) in control group with statistical difference (p 0.044). Also, their strong association with highly statistical difference between nasal injury stages and pain levels in both groups ($p<0.001$). **Conclusion**: The implementation of non-invasive respiratory support care bundle affect positively in decreasing preterm infants' nasal injury rate and their pain response in NICU. **Implications** for Practice: Further implementation of non-invasive respiratory support care bundle on large sample of preterm infants with non-invasive respiratory support and at another different settings. Future research about the application of mask versus nasal prongs should be examined.

Keywords: Nasal Injury, Non-Invasive Respiratory Support Care Bundle, Pain Response, Preterm Infants

Introduction

Preterm infants have the hazard of emerging respiratory complications because of the immaturity of their respiratory system, increased resistance of upper and lower airway due to muscles hypotonia, decreased lungs compliance and respiratory muscles weakness that associated with surfactant substance insufficiency. Not only oxygen therapy as enough treatment for neonatal hypoxemia and doesn't overcome the pathological respiratory disorders and many times require ventilator support **(Morley,2016).** Invasive mechanical ventilation (IMV) has been commonly used to assist preterm infants with respiratory failure. However, it was linked with several respiratory and non-respiratory problems, particularly in preterm infants. Short term respiratory problems comprise lung atelectasis, air leak syndromes, airway inflammation, pulmonary hemorrhage, ventilation associated pneumonia (VAP) and subglottic stenosis. Most serious long term respiratory complication for use of IMV

include bronchopulmonary dysplasia (BPD) which affects the preterm infants' lifestyle **(Torres-Castro et al.,2016).**

Consequently, the use of non-invasive ventilation (NIV) or non-invasive respiratory support (NIRS) expanded the attentiveness of healthcare providers in an effort to prevent respiratory complications and morbidity associated with IMV. Non-invasive respiratory support delivers ventilator support without used an artificial airway as [tracheostomy or endotracheal tube] **(Greenough & Lingam, 2016)**. At neonatal intensive care unit (NICU), binasal prong is the greatest frequently interface used in neonatology because it is less invasive, easy to use and has a lower cost. Also, it delivers relatively continual pressure permitting good access to the preterm infants. Moreover, binasal prong is effective in preventing reintubation and it provides less airflow resistance. Non-invasive ventilation enhances the stabilization of the upper airway and chest wall, decreases work of breathing, lung resistance and apneas, improves oxygenation, residual capacity and tidal volume as well as it is maintain upper airways patency and support the weak respiratory muscles (**Ribeiro et al., 2020; Sweet et al., 2013).**

However, an unintended and a significant negative consequences associated with extensive, prolonged use of NIRS is trauma and breakdown to nasal mucosa due to friction and pressure caused by the binasal prongs on the nasal septum and the columella, accordingly decreasing blood circulation, then tissue perfusion, and tissue ischemia**(Ribeiro, 2021).** Previous study reported, high prevalence of neonatal nasal injury (NI) rates associated with NIRS range from 20% - 60%. Adverse outcomes experienced by preterm infant with nasal injury comprise pain, excoriation, infection, tissue damage of nose which requesting plastics surgery, reintubation to permit period for nasal septum healing **(Milligan & Goldstein, 2017; Newnam et al.,2015)**. Nasal injuries are primarily categorized into stage I (hyperemia), then may progress to stage II (superficial ulceration), and stage III caractrized by nasal tissue necrosis and whole nasal tissue loss **(Imbulana, 2018; Shi et al., 2020)**.

The nasal injury may cause adverse consequences, and since nasal injury is a preventable problem utmost of the time, its avoidance is considered a fundamental aspect **(Coyer & Tayyib, 2017)**. To prevent nasal injuries, it is essential to recognize the neonates who are at high risk of developing nasal injury and cuasing factors such as low gestational age, more than 90% in preterm infants less than 28 weeks of gestational age, as well as low birth weight, long duration of NIRS, longer NICU stay and the nasal skin's sensitivity **(Bouza,2009)**. Therefore, identification of the problem lead to apply of suitable preventive measures. The nasal injury prevention is the best approach for newborns submitted to NIRS through implemented of the suitable prongs and interface siz, using masks substitute the prongs and using Velcro to maintain the prongs in the correct position, as well as observing the early signs of nasal injury and use of nasal protective barrier dressing could be effective intervention steps to decrease nasal injuries **(Alessi, 2018).**

Neonates admitted to NICU experience many painful and stressful procedures, NIRS can cause uneasiness, discmfort or even pain, particularly through nasal injuries, higher occurrence of nasal injury score in neonates was positively associated with higher pain level. Since the nasal injury is painful, it results in uneasiness, crying episodes, increased intracranial pressure and blood pressure may raise the risk of interventricular bleeding and accordingly, affects the newborn's motor development **(Vitaliti ,2012).** Uncontroled pain during this serious age of neonatal brain development is accompanying with immediate and long-term consequences. The pediatric nurse should assess the pain score during application of NIRS and implement pain mangement **(Collins et al., 2013)**. The use of non-pharmacological pain-relieving measures, including as non-nutritive sucking, kangaroo care, swaddling, holding, and oral sucrose, can help manage minor pain while severe pain requires the use of pharmacological drugs (**Pillai Riddell et al., 2011**).

A care bundle is a structured method of increasing the method of intervention resulting

in an improvement in patient outcomes. It's a straight forward, small set of evidence-based practical actions or interventions, that once performed reliably, improve patient outcomes **(Robb, 2010).** The implementation of a standardized evidence based nursing care bundle related to NIRS comprises; ensuring suitable position of the nasal prongs in the nostrils or the nasal mask, regular assessment of the nasal skin, gentle nasal septum and nasal bridge massage every day, ensuring a distance of 2 mm between the pronges and the nasal septum, providing humidified gas, use of hydrogel to lubricate the nasal skin, securing the nasal prongs with sensitive tape, usage of hydrocolloid nasal skin barrier and antimicrobial ointment for nasal skin damage have all been demonstrated to decrease the nasal injuries incidence with NIRS **(McCoskey, 2008 ; Ribeiro et al., 2020)**.

Standardization of practical intervention and emerging perfect pediatric nursing care steps for NIRS are essential for its good outcome**(Aly & Mohamed, 2020)**. Regular assessment of the nasal skin and nasal septum help the pediatric nurse to acquire accurate information about the occurrence of nasal injuries among preterm infants during NIRS, stresses the importance of planning and implementing preventive actions. Furthermore, in the cases of nasal injuries, it is possible to establish the stage of the nasal injury and thus lead appropriate therapeutic actions. and nursing supportive intervention may be decrease the occurrence of complications **(Nasef et al., 2020)**. Keeping the preterm infant's relaxation during NIRS care and regular evaluation of preterm infants may be decrease the occurrence of NIRS complications, Recognizing these complications will lead to better respiratory nurseing intervention and better outcomes for preterm infants **(Naha et al., 2019)**.

Significant of the study

Providing optimum ventilation approaches remains the important key to success of dealing and managing preterm infants. The use of (NIRS) early and extensively in the NICU has significantly reduced the requirement for endotracheal intubation and invasive ventilation, however, NIRS use is accompanying with nose injuries **(Naha et al., 2019)**. The Previous studies reported that increase incidence of nasal injury during NIRS use among neonates in NICU are common complications. Pain, excoriation, infection, loss of nasal tissue necessitating re-intubation, and eventually putting affected preterm infants at high risk for developing chronic lung disorders are some of the unfavourable outcomes of nasal skin injury in preterm infants **(Maffei 2017)**. The nasal injury is an adverse event with possible short-term and long-term consequences that is increasingly present in NICUs. Use of protective dressings and others evidence based practice applications and nursing intervention during NIRS are fundamental elements to prevent of nasal injury **(Xie 2014**). Hopefully, the current study would implement NIRS care bundle for preterm infants with non-invasive respiratory support that could decrease nasal injury rate and pain response among preterm infants in NICU.

Aim of the study

The aim of this study was to examine the effect of implement non-invasive respiratory support care bundle on preterm infants' nasal injury and pain response.

Hypotheses

I: The implementation of non-invasive respiratory support care bundle will decrease preterm infants' nasal injury rate in study group than control group.

II: The implementation of non-invasive respiratory support care bundle will decrease preterm infants' pain score in study group than control group.

III: Preterm infants in study group who had less nasal injury rate would exhibit less pain scores.

Operational definitions

- **Non-invasive respiratory support :** It's adminstration of the ventilator support without used an artificial airway such as [tracheostomy or endotracheal tube].

- **Nasal injury :** It's a simple nasal hyperemia, progress to necrosis, ends with the columella and nasal septum being destroyed. Nasal tissue injury impairs skin functions and allows infectious pathogens to enter the body.

- **Care Bundle**: It's a straight forward, small set of evidence-based practical actions or interventions, that once performed reliably, improve patient outcomes.

Subjects and Method

Design: In this study a quasi experimental Study/Control research design was utilized .

Setting:

This study was conducted on fifteen incubators in the level (II) of NICU at Al-Nasr Specialized Hospital for Children in cooperation with Cleopatra Hospitals Group (6 incubators) and El Salam Port Said Hospital in cooperation with El Salam International Hospital (9 incubators), Port Said Governorate, Egypt. That providing critical care for serious cases such as hyperbilirubenmia who are need phototherapy and/or blood exchange and respiratory distress syndrome [RDS] grades II and III that requisite invasive mechanical ventilation or non-invasive respiratory support.

Sampling

Based on data from literature **(Naha et al., 2019)**, considering level of significance of 5%, and power of study of 80%, the sample size can be calculated using the following formula:

$n = n = [2(Z_{\alpha/2} + Z_{\beta})^2 \times p\ (1-p)]/(p1 - p2)^2$, where, p = pooled proportion obtained from previous study; p1-p2 = difference in proportion of events obtained from previous study; , $Z_{\alpha/2}$ (=1.96, for 5% level of significance) and Z_{β} (equal 0.84 for 80% power of study). Therefore, $n= [2(1.96 + 0.84)^2 \times 0.66\ (1-0.66)]/(0.27)^2$=48.2, accordingly, the sample size required is 49 in each group.

Based on the above mentioned formula, the study sample composed of 98 preterm infants. They are divided randomly to 2 identical groups, the study group (49) who receive non-invasive respiratory support bundle, and the control group (49) who are given routine care based on the policy of NICU. The study sample was selected after fulfilling the inclusion criteria:

Inclusion criterion:

- Preterm infants have non-invasive respiratory support treatment.
- Both genders.
- Gestational age < 37 weeks of gestation .

Exclusion criteria:

- Infants have non-invasive respiratory support treatment for duration < 24 hrs.
- Pre-existing nasal injuries secondary to naso-tracheal intubation.
- Malformations of upper airway.
- Preterm infants referred from other centers after more than 24 hrs of non-invasive respiratory support treatment.
- Infants with life-threatening congenital anomalies, who had undergone any surgical operation.
- Infants with signs of nasal injury at the time of NIRS application .

Instrumentations:-

Tool 1 : Structured questionnaire:

After researching related literatures, the researchers designed this instrument to collect data on preterm infants' characteristics and their clinical data **Alsop et al., (2008); National Pressure Ulcer Advisory Panel, (2007)**. It include two parts:

Part 1: Characteristics of preterm infants: It involve data take out from preterm infant's medical folder and nurses' notes such as gender, gestational age , birth weight and postnatal age.

Part 2: Clinical data of preterm infants: Including diagnosis, NIRS mode used**,** duration of NIRS and duration of hospitalization .

Tool 2 : Nasal Injury Likert Scale:

This tool was adopted from **Alsop et al., (2008); European Pressure Ulcer Advisory Panel (EPUAP),(2009); Fischer et al., (2010); National Pressure Ulcer Advisory Panel, (2007).** It was used to description and classification of nasal trauma according to nasal skin affect through assess nasal area for erythema, ulcer and necrosis. This tool was assessed nasal injury through 4 parameters: nasal tip, nasal septum, nostril, and nose shape alteration. Nasal injury was classified into 3 stages as the following: Stage I: Charactrized by erythema with intact skin and not blanching, stage II: Superficial erosion or ulcer, with partial thickness skin loss and stage III:

Charactrized by nasal skin necrosis, with full thickness skin loss. When a preterm infants presented a nasal trauma developing through different stages, and should be treated early, not only the most severe stage was considered.

Scoring system:

Each parameter was scored a 5-point scale (0 to 4) except nose shape parameter was scored a 3-point scale (0 to 2), to give a maximum total score of 14, as the following:

Tip of nose (Normal skin scored zero,red skin scored 1, red and indent scored 2, red/indent/skin breakdown scored 3 and red/indent/skin breakdown and tissue loss scored 4), **Nasal septum** (Normal skin scored zero,red skin scored 1, red and indent scored 2, red/indent/skin breakdown scored 3 and red/indent/skin breakdown and tissue loss scored 4), **Nostrils** (Normal nostrils scored zero, enlarged nostrils scored 1, enlarged and prong shape scored 2 and Red, bleeding scored 3 and enlarged,red, bleeding and skin breakdown scored 4) and **nose shape** (Normal scored zero, pushed up/back but normal scored 1 and pushed up and shortened scored 2). An overall nasal injury score was calculated based on the examination, and it was then classified as no injury score (zero), stage I-mild (scores 1–4), stage II-moderate (scores 5–7), and stage III-severe (score > 7) **Alsop et al., (2008)**.

Tool 3 : Preterm Infant Pain Profile (PIPP) Likert Scale:

This tool was developed by **Bellieni et al., (2007); Stevens et al., (1996).** It was used to assess pain response of preterm infant at bedside (incubators). It was performed directly after application of non-invasive respiratory support treatment. The PIPP was consisted of a seven indicators for pain assessment that comprises 3 behavioral responses (eye squeeze, brow bulge and naso-labial furrow), 2 physiologic responses includes (heart rate and oxygen saturation), and 2 contextual responses (behavioral state and gestational age), behavioral state ranges from " eyes open, facial movements, active/awake" to " eyes closed, no facial movements, quiet/sleep".

Scoring system:-

Every indicator was given a score of zero to three on a four-point scale (zero to three), for a total score of 21, with score zero indicating no pain and score three indicating severe pain. The sum of total scores were classified into 3 categories, preterm infants with a total score of 0 to < 6 have minimal or no pain, while those with a score of 6 to 12 have mild to moderate pain, and those with a score of > 12 have severe pain **Bellieni et al., (2007); Stevens et al., (1996).**

Procedures for Data Collection

Data collection was conducted over a duration of 7 months from beginning of July 2021 till the end of January 2022. The researchers were accessible in the previous mentioned study settings three days per week from 9 A.m. to 12 p.m.

- **Validity of tools;** Tools of the current study were reviewed by a panel of 3 expertise in the neonatology and pediatric nursing before introduce it to the participants to confirm its validity and their notes were considered.
- **The reliability of tools**:It was tested through Cronbach's alpha test; 0.93 for the second **(Alsop et al., 2008)** and 0.95 for the third tool **(Bellieni et al., 2007)**.
- **Pilot study;** It was done on 10% of the studied preterm infants (n=9 preterm infants) to evaluate applicability , the clarity and feasibility of the tools and some changes were done. The pilot sample weren't included in the study.
- **Ethical considerations;** it was attained from the Faculty of Nursing Research Ethics Committee, Mansoura University. As well as, an formal approval was gained from the manager of hospital and the director of the NICU after an explanation the study aim, tools, period and the advantages. Additionally oral approval was gained from the mothers of the preterm infants after explanation of the study aims and advantages. They were assured about the privacy of the collected data. The parents were informed about their rights to be accepted or refuse participation of their preterm infants without interference with the care given to them.

• **The NIRS care bundle include many steps:** it was implemented for preterm infants in study group as the following:

• **Preterm infants in study group**

- The first assessment was conducted by the researchers for both groups before providing morning routine nursing care on the day prior to implementation of NIRS care bundle to gather data about characteristics of preterm infants and their clinical data using tool (1).

- The researchers were selected the study participants based on inclusion criteria and excluded the he preterm infants with excluded criteria.

- The non-invasive respiratory support care bundle is evidence based practice (EBP) bundle was designed by researchers to integrate (EBP) from the literature reviews **(Greenough & Lingam., 2016; Fischer, et al., 2010; Newnam et al., 2013)** into standardize and advance of the nursing care quality for preterm infants getting NIRS treatment.

- Implementation phase: The NIRS evidence based practice bundle included 6 core interventions:

(1) Use of properly sized nasal interface device: Use the nasal interface that doesn't occlude more than 50% of preterm infant's nostrils. Keep a gap of at least (2 mm) between the prongs and the nasal septum . Use a larger mask of (nCPAP) to permit nasal skin rest and healing of nasal tissue if nasal injuries happens.

(2) Use of protective hydrocolloid dressing barrier between nasal skin and nasal interface device: Usage of hydrocolloid nasal skin barrier, and apply of antimicrobial ointment for nasal skin trauma to decrease the danger of nasal injuries with NIRS. Use Duoderm under CPAP nasal prongs to protect the nose. Using a cut, fitting barrier between the nasal interface and the preterm infant's nasal skin can help in nasal skin injury prevention.

(3) Visually observing the preterm infant each hour to check and keep accurate nasal interface position: Frequent assessment of the nares every 3-6 hrs to notice for pressure areas in nares that may reduce perfusion, resulting in nasal injury and nasal skin necrosis. Select the proper fitting hat that is comfortable and not large.

(4) Briefly removing nasal device and protective barrier one time during a 12-hrs shift to conduct a thorough nasal skin assessment: Every 6-12 hours, remove the device and inspect the skin. Rotate between prongs and masks regularly to relieve pressure on nasal skin. Prongs position, wherever prongs didn't pull on nose even with preterm infants' head movement. Record any nasal skin redness, erosion, or abrasion is found. Apply massage of the nasal septum to enhance nasal blood circulation and facial muscles relaxation which affected by the NIRS. Use humidification to mobilize mucous secretions to prevent mucous plugging and nasal skin breakdown.

(5) Repositioning infant every three to 4 hrs using basic principles of developmental care: (providing comfortable position, repositioning and boundaries) . Appropriate position of preterm infant's head with neck rolls and blanket to prevent excessive movements of interface. In preterm infants supported with NIRS, prone and left lateral positions were linked with higher arterial oxygen saturation, better synchronisation of thoraco-abdominal movement and tidal volume than supine posture. The breathing circuits and nasal interface must be modefied when change of preterm infant's position to prevent nasal injury.

(6) Obtaining pain scores at least every 3 to 4 hrs.

The researchers were assessed preterm infants pain level by using tool (3), 5 minutes before painful procedures with while the infant is calm every 3-4 hrs from the first day of NIRS treatment until its weaning. The pain scores were calculated, and then classify the preterm infant's pain level.

- The researchers were apply the consistent education , demonstration and training of all the nurses staff which ensures that all nurses are providing the NIRS care bundle with the same preterm infant nasal septum care throughout the day during the routine care for infants in study group to adopt the uniform practices may decrease or prevent nasal tissue injury.

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he researchers were trained the nurses for careful observation of the preterm infant's nose

every 30–60 minutes during NIRS, which was temporary removed every 2–4 hrs to permit closer local inspection. This nasal inspection was external and not by instruments, thus it's possible that isolated internal nostrils trauma was missed.

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he researchers and nurses were perform nasal injury monitoring and scoring. Also, position of nasal prongs were observed and recorded in an organized monitoring sheet every 6 hrs from the first day of NIRS treatment until its weaning.

- **Preterm infants in control group:** Gather data about characteristics of preterm infants and their clinical data using tool (1). They were received routine nursing care for NIRS according to NICU policy.

- **Evaluation NIRS care bundle:** The NIRS care bundle intervention was evaluated after intervention using previously mentioned tools of data collection for study group's preterm infants.

- Evaluation and documentation of nasal skin assessments among the studied preterm infants to evaluate the nasal injury score in both groups by researchers every 3-6 hrs from the first day of NIRS until its weaning.

- Evaluation of the pain score was done by researchers for preterm infants in both groups every 3-4 hrs from the first day of NIRS treatment until its weaning.

- Comparison between the study and control group's findings was done to evaluate the effect of application of NIRS care bundle on preterm infants' nasal injury and pain responses in study group.

Statistical Design

All statistical analyses were performed using SPSS for windows version 20.0 (SPSS, Chicago, IL). Continuous data were normally distributed and were expressed in mean ±standard deviation (SD). Categorical data were expressed in number and percentage. One-way analysis of variance (ANOVA) test was used for comparison among more than two variables with continuous data while Student's t test was used for comparison between two variables with continuous data. Chi-square test was used for comparison of variables with categorical data. The reliability (internal consistency) test for the questionnaires used in the study was calculate. Statistical significance was set at $p<0.05$.

Results:

Table (1): presents characteristics of preterm infants, more than half of preterm infants were male (57.1%) in study group and (53.1%) in control group with mean gestational age was 30.1 ±2.9 wks in study group, and 30.1 ±3.0 wks in control group. The mean birth weight was 2248.3 ±661.2 gm in study group and 2256.7 ±672.1 gm in control group. The postnatal age mean mean of the preterm infants was 11.5 ±5.1 days in study group and 12.7 ±4.4 days in control group. There was no statistical difference between the two groups [$p>0.05$].

Table (2): Shows clinical data of the preterm infants in the study and control groups. It was clear that less than half of preterm infants were used NIRS were diagnosed with respiratory distress syndrome (40.8%) in study group and transient tachypnea of the newborn (42.9%) in control group. Regarding NIRS mode used, more than half (53.1%) of preterm infants in study group were used (HHHFNC) and (55.1%) of preterm infants in control group were used (nCPAP). Concerning duration of NIRS, more than half (59.2 %) of preterm infants in study group and (61.2%) of preterm infants in control group were used NIRS for 7-<10 days with mean (8.9 ±2.4 & 8.3 ±2.5 respectively) in both groups. There is no statistical difference between both groups.

Figure (1): Illustrates the mean of duration of hospitalization (days) (Mean ±SD) in both groups, it was evident that the mean duration of hospitalization was 22.1 ±4.2 days in study group and 28.2 ±4.5 days in control group with highly statistical difference between both groups [$p<0.001$].

Table (3): Illustrates the comparison of nasal injury parameters and severity post intervention in the study and control groups. It was found that about one third (26.5%) of preterm infants in study group have no nasal injury post intervention compared with minority (10.2%) of preterm infants in control group with statistical difference [p value 0.048]. Regarding nasal injury severity, it was found that more than half (53.1%) of preterm infants in study group have mild nasal injury post intervention compared with one third (34.7%) in control group with mean (**2.8 ±1.1&4.4 ±2.1** respectively) in both groups post intervention. Also, none of preterm infants in study group have severe nasal injury compared with minority(8.2%) of preterm infant in control group, with highly

statistical difference between both groups [p<0.001].

Figure (2): Illustrates the pain score in the study and control groups post intervention, it was observed that more than one third (34.7%) of preterm infants in study group have no – minimal pain level post intervention compared with minority (14.3%) in control group, with statistical difference [p value 0.044].

Figure (3): Shows the total pain score in the study and control groups post intervention, it was found that the total pain score mean was (7.5 ±3.4 & 9.4 ±4.2 respectively) in study and control groups post intervention with statistical difference [p value 0.020].

Table (4): Shows the association between studied preterm infant's nasal injury and pain responses and duration of hospitalization post intervention in study and control groups, it was observed that their strong association with highly statistical difference between nasal injury stages and pain levels in study and control groups (p<0.001), the preterm infant with no nasal injury have no-minimal pain, also, stage 2 –moderate and stage 3- severe nasal injury have severe pain level. Concerning duration of hospitalization, it was clear that their statistical difference between nasal injury stages and duration of hospitalization in study and control groups [p 0.02].

Table (5): Shows relation between NIRS mode used and pain levels among preterm infants in both groups post intervention, it was clear that pain scores were significantly higher in preterm infants with (nCPAP) compared with (HHHFNC). None of the preterm infants in the study group whose used HHHFNC mode had severe pain compared with minority (13.6%) of the preterm infants in control group with statistical significant in both groups [P<0.05].

Table (6): presents relation between characteristics of preterm infants and stage of nasal injuries in both groups post intervention, it was observed that severity of nasal injuries were significantly higher in preterm infants gestational age less than 28 weeks and birth weight <1000 gms, it is mean their inversely relation. Similarly, severity of nasal injury were significantly higher in preterm infants were used NIRS for 10 days or more and nasal injuries were significantly higher in those preterm infants who received of (nCPAP) in comparison to (HHHFNC) modes. Their highly statistical significant in both groups [P<0.001

Table 1. Characteristics of the Preterm Infants in the Study and Control Groups (n=98)

Characteristics of the preterm infants	Study group (n=49)		Control group (n=49)		X^2	P
	No.	%	No.	%		
Gender						
Male	28	**57.1**	26	**53.1**		
Female	21	42.9	23	46.9	0.165	0.685
Gestational age (weeks)						
< 28 Weeks	11	22.4	10	20.4		
28 – 31 Weeks	25	51.0	23	46.9		
32 – <37 Weeks	13	26.5	16	32.7	0.441	0.802
Mean ±SD	**30.1 ±2.9**		**30.1 ±3.0**		**0.034**	**0.973**
Birth weight (gm)						
< 1000	9	18.4	7	14.3		
1000 – 1499	14	28.6	11	22.4		
1500 – 2499	16	32.7	19	38.8		
≥ 2500	10	20.4	12	24.5	1.049	0.789
Mean ±SD	**2248.3 ±661.2**		**2256.7 ±672.1**		**0.062**	**0.950**
Postnatal age (days)						
1 – 7 days	9	18.4	8	16.3		
8 – 14 days	24	49.0	22	44.9		
>14 days	16	32.7	19	38.8	0.403	0.818
Mean ±SD	**11.5 ±5.1**		**12.7 ±4.4**		**1.221**	**0.225**

Table 2. Clinical Data of the Studied Preterm Infants in the Study and Control Groups (n=98)

	Study group (n=49)		Control group (n=49)		X^2	P
Clinical data of the preterm infants	No.	%	No.	%		
Diagnosis						
Transient tachypnea of the newborn	18	36.7	21	**42.9**		
Respiratory distress syndrome	20	**40.8**	18	36.7		
Meconium aspiration	9	18.4	7	14.3		
Congenital heart disease	2	4.1	3	6.1	0.786	0.852
NIRS mode used						
nCPAP	23	46.9	27	**55.1**		
HHHFNC	26	**53.1**	22	44.9	0.653	0.418
Duration of NIRS						
< 7 days	4	8.2	6	12.2		
7 - <10 days	29	**59.2**	30	**61.2**		
10 days or more	16	32.7	13	26.5	0.727	0.695
Mean SD	**8.9 ±2.4**		**8.3 ±2.5**		**1.037**	**0.302**
Duration of hospitalization (days) (Mean ±SD)	22.1 ±4.2		28.2 ±4.5		4.925	**<0.001****

**Highly statistically significant P <0.001

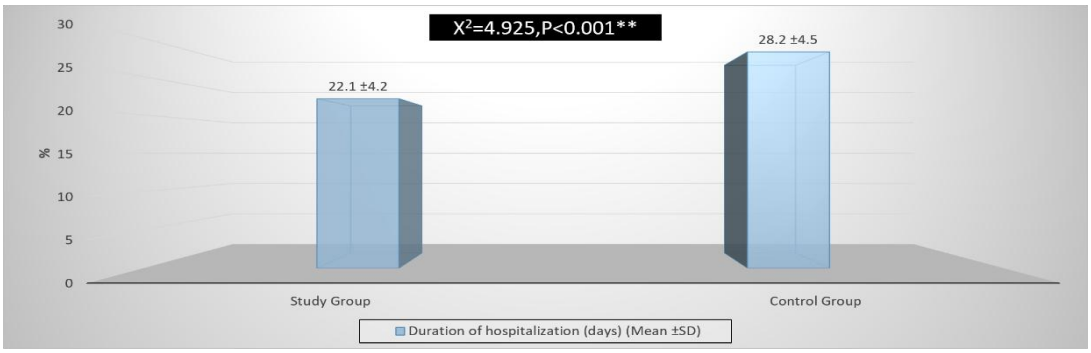

Figure 1. Distribution of the Duration of Hospitalization (days) (Mean ±SD) in the Study and Control Groups (n=98)

Answer the first hypothesis

The implementation of non-invasive respiratory support care bundle will decrease preterm infants' nasal injury rate in study group than control group.

Table 3. The Comparison of Nasal Injury Parameters and Nasal Injury Severity in the Study and Control Groups Post Intervention (n=98)

	Study group (n=49)		Control group (n=49)		X^2	P
Variables	**No.**	**%**	**No.**	**%**		
Nasal injury parameters						
No nasal injury	13	**26.5**	5	**10.2**		
Nasal tip injury	24	49.0	19	38.8		
Nasal septum injury	4	8.2	11	22.4		
Nostril injury	8	16.3	13	26.5		
Nose shape altered	0	0.0	1	2.0	9.594	**0.048***
Nasal injury Severity						
No nasal injury	13	26.5	5	10.2		
Stage 1- Mild	26	**53.1**	17	**34.7**		
Stage 2- Moderate	10	20.4	23	46.9		
Stage 3- Severe	0	0.0	4	8.2	14.560	**0.002***
Severity score (Mean ±SD)	**2.8 ±1.1**		**4.4 ±2.1**		**4.724**	**<0.001****

**Highly statistically significant P <0.001 * Statistically significant p ≤ 0.05.

Answer the second hypothesis

The implementation of non-invasive respiratory support care bundle will decrease preterm infants' pain score in study group than control group.

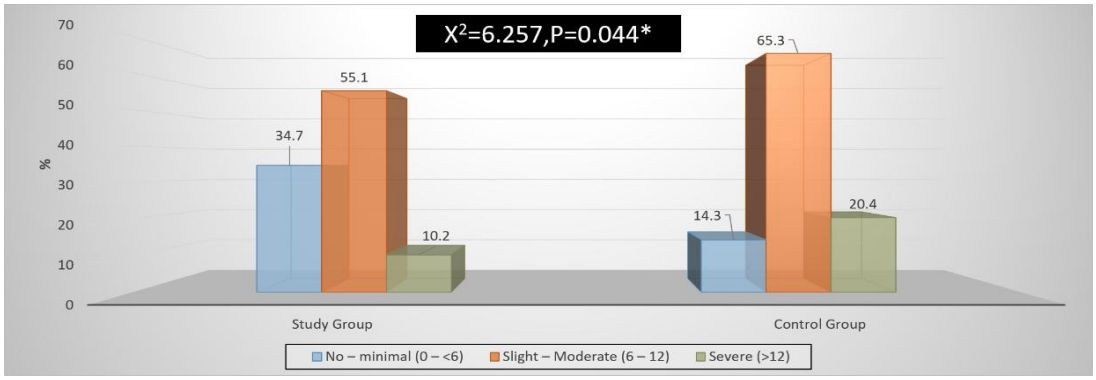

Figure 2: The Comparison of Pain Score in the Study and Control Groups Post Intervention (n=98)

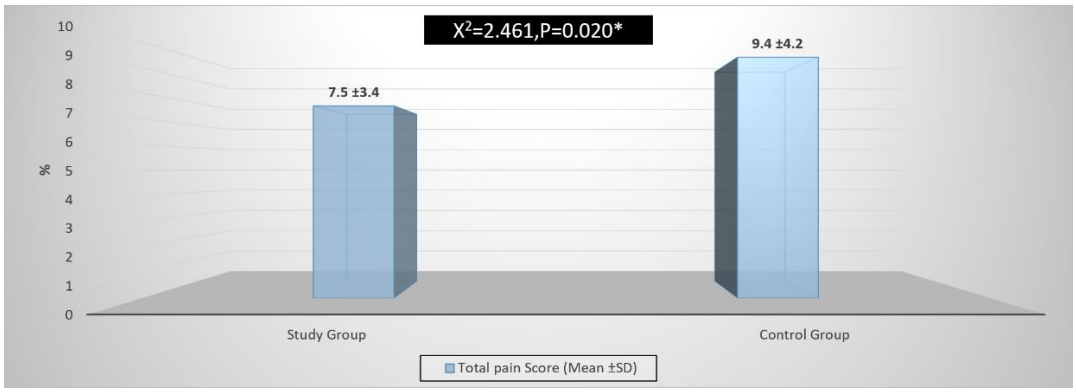

Figure 3. Distribution of Total Pain Score (Mean ±SD) in the Study and Control Groups Post Intervention (n=98)

Answer the third hypothesis

Preterm infants in study group who had less nasal injury rate would exhibit less pain scores.

Table 4. The Association Between Studied Preterm Infant's Nasal Injury and Pain Responses and Duration of Hospitalization in Study and Control Groups Post Intervention (n= 98)

	Study group (n=49)						**Control group (n=49)**					
Variables	No injury (n=13)		Mild (n=26)		Moderate (n=10)		No injury (n=5)		Mild (n=17)		Moderate (n=23)		Severe (n=4)	
Pain Levels	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
No – minimal (0 – < 6)	13	100.0	4	15.4	0	0.0	5	100.0	2	11.8	0	0.0	0	0.0
Slight – Moderate (6 – 12)	0	0.0	22	84.6	5	50.0	0	0.0	15	88.2	17	73.9	0	0.0
Severe (> 12)	0	0.0	0	0.0	5	50.0	0	0.0	0	0.0	6	26.1	4	100.0
X^2 [P]	X^2=53.065 [P<0.001]**						X^2=54.424 [P<0.001] **					
Duration of hospitalization (days) (Mean ±SD)	**18.6 ±4.7**		**22.2 ±4.6**		**26.0 ±2.6**		**22.0 ±3.6**		**26.9 ±4.1**		28.8 ±4.6		34.5 ±3.5	
F [P]	F=4.834 [P=0.020] *						F= 3.702 [P= 0.025] *					

**Highly statistically significant P <0.001 * Statistically significant p ≤ 0.05.

Table (5): Relation Between NIRS Mode Used and Pain Levels Among Preterm Infants in Both Groups Post Intervention (n=98)

Variables	Study group (n=49)				Control group (n=49)			
	nCPAP (n= 23)		HHHFNC (n=26)		nCPAP (n= 27)		HHHFNC (n=22)	
Pain levels	No.	%	No.	%	No.	%	No.	%
No – minimal (0 – < 6)	3	13.0	14	53.8	1	3.7	6	27.3
Slight – Moderate (6 – 12)	15	65.2	12	46.2	19	70.4	13	59.1
Severe (> 12)	5	21.7	0	0.0	7	25.9	3	13.6
Chi-Square Test	X^2= 12.313 [P=0.002]*				X^2= 5.847 [P=0.053]*			

* Statistically significant p ≤ 0.05.

Table 6. Relation Between Characteristics of Preterm Infants and Stage of Nasal Injury in Both Groups Post Intervention (n=98)

	Study group (n=49)						Control group (n=49)							
Variables	No injury (n=13)		Mild (n=26)		Moderate (n=10)		No injury (n=5)		Mild (n=17)		Moderate (n=23)		Severe (n=4)	
Gestational age (weeks)	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
< 28 Weeks	0	0.0	4	15.4	7	70.0	0	0.0	5	29.4	1	4.3	4	100.0
28 – 31 Weeks	7	53.8	16	61.5	2	20.0	1	20.0	10	58.8	12	52.2	0	0.0
32 – < 37 Weeks	6	46.2	6	23.1	1	10.0	4	80.0	2	11.8	11	43.5	0	0.0
X^2 [P]	X^2= 19.072 [P<0.001]**						X^2= 28.151 [P<0.001]**							
Birth weight (gm)														
< 1000	0	0.0	3	11.5	6	60.0	0	0.0	2	11.8	1	4.3	4	100.0
1000 – 1499	1	7.7	9	34.6	4	40.0	0	0.0	7	41.2	4	17.4	0	0.0
1500 – 2499	2	15.4	14	53.8	0	0.0	1	20.0	8	47.1	10	43.5	0	0.0
≥2500	10	76.9	0	0.0	0	0.0	4	80.0	0	0.0	8	34.8	0	0.0
X^2 [P]	X^2= 50.979 [P<0.001]**						X^2= 42.756 [P<0.001]**							
Duration of NIRS (days)														
< 7	4	30.8	0	0.0	0	0.0	5	100.0	1	5.9	0	0.0	0	0.0
7 – < 10	9	69.2	20	76.9	0	0.0	0	0.0	16	94.1	14	60.9	0	0.0
10 or more	0	0.0	6	23.1	10	100.0	0	0.0	0	0.0	9	39.1	4	100.0
X^2 [P]	X^2= 37.465 [P<0.001]**						X^2= 59.180 [P<0.001]**							
NIRS mode used														
nCPAP	2	15.4	12	46.2	9	90.0	1	20.0	5	29.4	17	73.9	4	100.0
HHHFNC	11	84.6	14	53.8	1	10.0	4	80.0	12	70.6	6	26.1	0	0.0
X^2 [P]	X^2= 12.648 [P<0.001]**						X^2= 13.574 [P=0.003]*							

**Highly statistically significant P <0.001 * Statistically significant p ≤ 0.05.

Discussion

Over the last few decades, IMV has been widely used to help high-risk infants with respiratory failure or respiratory distress. Though it was used mostly in premature infants, it was linked to many of respiratory and non-respiratory problems, especially short-term respiratory problems **(Torres-Castro et al.,2016)**. Non-invasive ventilation has been broadly used in the treatment of the preterm infants with respiratory insufficiency with significant enhancement in preterm infants' respiratory outcomes compared to IMV, though,

a significant and accidental adverse consequences associated with prolonged, extensive use of NIRS is nasal skin mucosa breakdown and injury. Used of NIRS in a variety of ways in several trials. Surprisingly, clinical consequences of the same NIRS mode varied significantly throughout neonatal intensive care units, highlighting the vital need of nursing practice in efficiently supporting preterm infants with NIRS. **(Newnam et al., 2015)**. Hence, this study was aimed to examine the effect of implement non-invasive respiratory support care bundle on preterm infants' nasal injury and pain response.

Regarding preterm infants' characteristics (**Table1**), the results of current study illustrated that, in the study group, more than half of the preterm infants were male and control group with mean gestational age were 30.1 ±2.9 wks in study group and 30.1 ±3.0 wks in control group. This result was congruent with **Khan et al., (2017)** who found that mean gestational age were (29.9 ± 2.3 and 29.6 ± 2.2 respectively) in intervention and control groups. Also, the result of this study revealed that the mean birth weight was 2248.3 ±661.2 gm in study group and 2256.7 ±672.1 gm in control group with mean postnatal age of the preterm infants were (11.5 ±5.1 days and 12.7 ±4.4 days) respectively in both groups. This finding was disagreement with **Chen et al., (2020)** who showed that mean birth weight were (827 ± 23.0 & 794 ± 31.0 respectively) in HHHFNC and NCPAP groups.

Concerning clinical data of the preterm infants **(Table 2).** The findings of the current study was revealed that less than half of preterm infants used NIRS were diagnosed with respiratory distress syndrome in study group and less than half of preterm infants used NIRS were diagnosed with transient tachypnea of the newborn in control group, this could be attributed to preterm infants have immaturity of the respiratory system so that, they have high risk of developing respiratory complications and need for respiratory support. This result was inconsistency with **Fischer et al., (2010)** who illustrated that less than half of preterm infants used (nCPAP) were diagnosed with transient tachypnea of the newborn and minority of them were diagnosed with respiratory distress syndrome.

The result of this study illustrated that NIRS mode used, more than half of preterm infants in study group were used (HHHFNC) and the preterm infants in control group were used (nCPAP).This result was discongruent with **Newnam et al., (2013)** who displayed that less than half of preterm infant used (nCPAP) in exprimental and control groups with no statistical difference was demonstrated between both groups. On the other hand, this result was disagreement with **Waskosky, & Huey, (2014)** who stated that more than two third of preterm infants in the intervention group were managed with CPAP compared with minority of the preterm term infants in control group. This may be attributed to that the most common NIRS modes used in different NICUs are CPAP and HHHFNC.

Regarding duration of NIRS, the current study revealed that more than half of preterm infants in study group and control group were used NIRS for 7-<10 days with mean (8.9 ±2.4 days & 8.3 ±2.5 days) respectively in both groups. This result was disagreement with **Ribeiro et al., (2021**) who found that mean time of non-invasive ventilation were (106:26 ± 81:35 hours & 118:49 ± 80:33 hours). This may be attributed to use of NIRS for long time may increase susceptibility for nasal injury due to continous pressure of nasal prongs on vulnerable preterm infants' nasal skin.

In relation mean duration of hospitalization was 22.1 ±4.2 days in study group and 28.2 ±4.5 days in control group with highly statistical differences between both groups ($p<0.001$) **(Figure 1)**. This finding was disagreement with **Osman et al., (2015)** who found that duration of hospitalization was (27 days & 24 days) respectively in nCPAP and HHHFNC groups. This may be attributed to positive effect of the intervention on preterm infants in study group than those in control group, while nasal injury rate was decreased in the preterm infants in study group post intervention. Nasal injury considerd acomplication which can increase length of

hospital stay due to its treatment need long periode according to stage of nasal injury.

Answer the first hypothesis regarding comparison of nasal injury parameters and severity post intervention in the study and control groups **(Table 3).** The result of the current study showed that about one third of preterm infants in study group have no nasal injury post intervention compared with minority of preterm infants in control group with statistical difference (p 0.04). This result was supported by **Imbulana et al., (2018)** who found that infants in the nasal barrier group had a significantly lower rate of nasal injury compared with the no nasal barrier group with statistical difference between both groups. Also, this finding was in the same line of **Rezaei et al., (2021)** who found that infants in the exprimental group had a significantly lower incidence and severity of nasal injuries than infants in the control group (P < .001), general, the nasal injuries in thier study were commonly mild and moderate, with merely 3 cases have severe nasal injuries in the exprimental group and 5 cases in the control group. This might be attributed the positive effect of NIRS care bundle resulting in decrease nasal injury rate in preterm infants in study group more than preterm infants in control group.

Concerning nasal injury severity, the finding of the current study showed that more than half of preterm infants in study group have mild nasal injury post intervention compared with one third in control group with mean (2.8 ±1.1&4.4 ±2.1 respectively) in both groups post intervention, as well as, none of preterm infants have severe nasal injury in study group compared with minority of preterm infant in control group with highly statistical difference between both groups (p<0.001). This result in the same direction with **Ribeiro et al., (2021**) who found that about two third of the nasal injuries were classified as stage I, while one third presented stage II and non-occurrence of nasal injuries stage III after implementation of the protocol about nasal protections during NIV. On the other hand, this result was discongruent with **Sousa et al., (2013)** who assessed (47 preterm infants) who needed NIRS with nasal prongs, and they found 32 cases of nasal injuries in about two third of infants from them was classified as stage I, half of them have stage II, and minority of them have stage III. They confirmed that they had not applied nasal protection for preterm infants in control group was used NIV, this is most reason for the more nasal injuries in this group. Those discrepancy may be attributed to implementation of NIRS care bundle to protect nose of the preterm infants during period of NIRS treatment and this interventions may have been the reason for the absence of sever nasal injury in study group.

Answer the second hypothesis regarding pain score post intervention in the study and control groups. The finding of this study illustrated that more than one third of preterm infants in study group have no – minimal pain level post intervention compared with minority of preterm infants in control group, the total pain score mean was (**7.5 ±3.4 & 9.4 ±4.2** respectively) in both groups post intervention with statistical difference (p 0.020) **(Figure 2&3).** This result was supported with **Imbulana et al., (2018)** who stated that NIV can induce discomfort or even pain for neonates, especially if they have a nasal injury. On the other hand, this finding was inconsistent with **Klingenberg et al.,(2014)** who concluded that the cumulative pain score was about 11 in CPAP and HHHFN groups, with mean pain score less than 4 for each of the 3 pain assessments' parameters in both groups, without significant differences between both groups, This shows that in their study, both ventilator strategies provided satisfactory comfort. This could be attributed to positive effect of intervention on decrease nasal injury rate and accordingly pain level was decreased among preterm infants in the study group than those in control group.

Answer of the third hypothesis concerning the association between studied preterm infant's nasal injury and pain responses and duration of hospitalization post intervention in study and control groups, the result of the current study was revealed that their positive association with highly statistical difference between nasal injury stages and pain levels in study and control groups (p<0.001), the preterm infant with no nasal injury have no-minimal

pain, also, stage 2 –moderate and stage 3-severe nasal injury have severe pain level **(Table 4)**. This result was supported with **Khan, et al., (2017)** who found that the score of nasal injury was positively correlated with pain score demonstrating the potential long-term effects of nasal injury and the requisite for more frequent nursing assessment and better nursing intervention. This might be attributed to effect of intervention on nasal injury among preterm infants in study group resulting in decreased pain level more than preterm infants in control group.

Concerning duration of hospitalization, the finding of the current study showed that their statistical difference between nasal injury stages and duration of hospitalization in study and control groups with statistical difference between both groups (p 0.02). it is mean that nasal injury stages 1,2&3 needs long period for hospital stay accordingly with statistical difference in both group. This result was agreement with **Tauzin& Durrmeyer, (2019)** they found that premature neonates can receive continuous NIV for long periods of time during their hospital stay, which can last many weeks or even months in the case of the most preterm infants. In addition, this finding was supported by **Galetto et al., (2019)** who stated that the necessity for antibiotic medication as a result of the infection induced by the nasal wound or the need for reintubation may lengthen the hospital stay. This might be attributed to moderate and severe nasal injury need long period for hospital stay more than preterm infant without nasal injury and mild nasal injury.

Regarding the relation between NIRS mode used and pain levels among preterm infants in both groups post intervention **(Table 5),** the result of this study showed that pain scores were significantly higher in preterm infants with (nCPAP) compared with (HHHFNC). None of the preterm infants in the study group whose used HHHFNC mode had severe pain. There highly statistical significant in both groups [P<0.05]. This result was consistent with **Osman et al., (2015)** who assessed pain level in infants with NCPAP and HHHFNC, and they observed that infants whose use HHHFNC had significantly less pain level and improved their tolerance than infants whose use NCPAP. Also, this finding was agreement with **Collins et al., (2014)** who stated that during use of nCPAP, nasal prongs and masks are the most prevalent causes of nasal injuries, which can result in permanent deformity. Also those results was in line with **Fernandez et al., (2014)** who stated that HHHFNC, are lighter, smaller, don't need to be snuggly inserted into the neonate's nostrils, which may cause less discomfort during insertion and contribute to less nasal injury compared with nCPAP as observed in the current study and in the previous studies. This may be due to the prongs of nCPAP are thick and designed to seal into the nares to keep a consistent airway pressure, so it is resulting in frequent friction with nares causing nasal injury.

Concerning relation between characteristics of preterm infants and stage of nasal injury in both groups post intervention **(Table 6).** The result of the current study was revealed that severity of nasal injury were significantly higher in preterm infants gestational age less than 28 weeks and birth weight <1000 gm, it is mean their inversely relation. Similarly, severity of nasal injury were significantly higher in preterm infants were used NIRS for 10 days or more and significantly higher in those preterm infants who received (nCPAP) in comparison to (HHHFNC).Their highly statistical significant in both groups [P<0.001]. This result was consistent with **Ribeiro, et al., (2021)** who observed that lower birth weight and preterm infants, as well as those who were exposed to NIV for long periods of time, experienced more severe nasal injuries. These results are similar to other previouse studies. Also this result in the same line of **Imbulana et al., (2018)** who observed that low-birth weight neonates and preterm infants are susceptible to nasal injuries because of the immaturity of their integumentary system. The preterm infants have immature of epidermal barrier, which increase the skin injury rate when the skin was compressed. As well as this result was consistent with **Fischer et al.,(2010)** who found that occurrence and severity of nasal trauma were inversely correlated with birth weight and gestational age. The risk of nasal trauma was

larger in neonates less than 32 weeks of gestational age, weighing <1500 gm at birth. Additionally, this results was agreement with **Chen et al., (2020)** who concluded that the premature infants with HHHFNC have shortens time of oxygen consumption and significantly diminishes the incidence of nasal injuries and necrotizing enterocolitis; furthermore, it can also decrease the length of hospital stay and the hospitalization costs. This due to the preterm infants have immature skin barrier, which lead to easy skin breakdown and injury once some parts are compressed especially for long period.

In relation to severity of nasal injury and time of used NIRS. The findings of the current study illustrated that severity of nasal injury were significantly higher in preterm infants were used NIRS for 10 days or more. This result was consistent with **Bonfim, et al., (2014)** who found that the preterm infants whose have longer periods on NIV, they have the higher risk of developing nasal skin damage. These results are similar to the result of study was conducted by **Alessi, (2018)** who concluded that the preterm infant who stay in NICU for long times under NIV is more liable to nasal injury, this as a result of the immaturity of preterm infants' skin and they are more vulnerable to develop skin injuries. In addition, the immaturity of the preterm infants' respiratory system commonly needs longer periods in NIVand rising the probability of developing nasal injuries**.**

Conclusion

The implementation of non-invasive respiratory support care bundle affect positively in decreasing preterm infants' nasal injury rate and their pain response in NICU.

Implications for Practice

- Further implementation of non-invasive respiratory support care bundle on large sample of preterm infants with non-invasive respiratory support and at another different settings.
- An educational program for neonatal nurses and respiratory therapists with a concentrates on preterm infants' skin care while on NIRS.
- Future research about the application of mask versus nasal prongs should be examined.

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References

Alessi, S. (2018). Evidence regarding the use of bubble continuous positive airway pressure in the extremely low birth-weight infant: benefits, challenges, and implications for nursing practice. Advances in Neonatal Care, 18(3), 199-207.

Alsop, E. A., Cooke, J., Gupta, S., & Sinha, S. K. (2008). Nasal trauma in preterm infants receiving nasal continuous positive airway pressure. Arch Dis Child 93(Supplement 2):n23

Aly, H., & Mohamed, M. A. (2020). An experience with a bubble CPAP bundle: is chronic lung disease preventable?. Pediatric research, 88(3), 444-450.

Bellieni, C. V., Cordelli, D. M., Caliani, C., Palazzi, C., Franci, N., Perrone, S., ... & Buonocore, G. (2007). Inter-observer reliability of two pain scales for newborns. Early human development, 83(8), 549-552.

Bonfim, S. D. F. S. F., Vasconcelos, M. G. L. D., Sousa, N. F. C. D., Silva, D. V. C. D., & Leal, L. P. (2014).. Nasal septum injury in preterm infants

using nasal prongs. Rev Lat Am Enfermagem. 22(5):826–833.

Bouza, H. (2009). The impact of pain in the immature brain. The Journal of Maternal-Fetal & Neonatal Medicine, 22(9), 722-732.

Chen, J., Lin, Y., Du, L., Kang, M., Chi, X., Wang, Z., ... & Chen, Y. (2020). The comparison of HHHFNC and NCPAP in extremely low-birth-weight preterm infants after extubation: a single-center randomized controlled trial. Frontiers in pediatrics, 13(2), 250.

Collins, C. L., Barfield, C., Horne, R. S. C., & Davis, P. G. (2014). A comparison of nasal trauma in preterm infants extubated to either heated humidified high-flow nasal cannulae or nasal continuous positive airway pressure. European journal of pediatrics, 173(2), 181-186.

Collins, C. L., Holberton, J. R., Barfield, C., & Davis, P. G. (2013). A randomized controlled trial to compare heated humidified high-flow nasal cannulae with nasal continuous positive airway pressure postextubation in premature infants. The Journal of pediatrics, 162(5), 949-954.

Coyer, F., & Tayyib, N. (2017). Risk factors for pressure injury development in critically ill patients in the intensive care unit: a systematic review protocol. Systematic reviews, 6(1), 1-6.

European Pressure Ulcer Advisory Panel E.P.U.A.P and National Pressure Ulcer Advisory Panel (2009). Prevention and treatment of pressure ulcers: quick reference guide. Washington, DC: National Pressure Ulcer Advisory Panel.

Fernandez-Alvarez, J. R., Gandhi, R. S., Amess, P., Mahoney, L., Watkins, R., & Rabe, H. (2014). Heated humidified high-flow nasal cannula versus low-flow nasal cannula as weaning mode from nasal CPAP in infants≤ 28 weeks of gestation. European journal of pediatrics, 173(1), 93-98.

Fischer, C., Bertelle, V., Hohlfeld, J., Forcada-Guex, M., Stadelmann-Diaw, C., & Tolsa, J. F. (2010). Nasal trauma due to continuous positive airway pressure in neonates. Archives of Disease in Childhood-Fetal and Neonatal Edition, 95(6), F447-F451.

Galetto, S. G. D. S., Nascimento, E. R. P. D., Hermida, P. M. V., & Malfussi, L. B. H. D. (2019).. Medical device-related pressure injuries: an integrative literature review. Rev Bras Enferm. 72(2):505–512.

Greenough, A., & Lingam, I. (2016). Invasive and non-invasive ventilation for prematurely born infants–current practice in neonatal ventilation. Expert review of respiratory medicine, 10(2), 185-192.

Imbulana, D. I., Manley, B. J., Dawson, J. A., Davis, P. G., & Owen, L. S. (2018). Nasal injury in preterm infants receiving non-invasive respiratory support: a systematic review. Archives of Disease in Childhood-Fetal and Neonatal Edition, 103(1), F29-F35.

Imbulana, D. I., Owen, L. S., Dawson, J. A., Bailey, J. L., Davis, P. G., & Manley, B. J. (2018). A randomized controlled trial of a barrier dressing to reduce nasal injury in preterm infants receiving binasal noninvasive respiratory support. The Journal of pediatrics, 201, 34-39.

Khan, J., Sundaram, V., Murki, S., Bhatti, A., Saini, S. S., & Kumar, P. (2017). Nasal injury and comfort with jet versus bubble continuous positive airway pressure delivery systems in preterm infants with respiratory distress. European Journal of Pediatrics, 176(12), 1629-1635.

Klingenberg, C., Pettersen, M., Hansen, E. A., Gustavsen, L. J., Dahl, I. A., Leknessund, A., & Nordhov, M. (2014). Patient comfort during treatment with heated humidified high flow nasal cannulae versus nasal continuous positive airway pressure: a randomised cross-over trial. Archives of Disease in Childhood-Fetal and Neonatal Edition, 99(2), F134-F137.

Maffei, G., Gorgoglione, S., & Vento, G. (2017). Noninvasive ventilation: systematic approach and new perspectives for preterm infants. Journal of Clinical Neonatology, 6(3), 135.

McCoskey, L. (2008). Nursing care guidelines for prevention of nasal breakdown in neonates receiving nasal CPAP. Advances in Neonatal Care, 8(2), 116-124.

Milligan, P. S., & Goldstein, M. R. (2017). Implementation of an evidence-based non-invasive respiratory support (NIRS) bundle in the NICU to decrease nasal injury complications. Journal of Neonatal Nursing, 23(2), 89-98.

Morley, S. L. (2016). Non-invasive ventilation in paediatric critical care. Paediatric respiratory reviews, 20(2), 24-31.

Naha, N., Pournami, F., Prabhakar, J., & Jain, N. (2019). Nasal injury with continuous positive airway pressure: need for "privileging" nursing staff. The Indian Journal of Pediatrics, 86(7), 595-598.

Nasef, N., Rashed, H. M., & Aly, H. (2020). Practical aspects on the use of non-invasive respiratory support in preterm infants. International Journal of Pediatrics and Adolescent Medicine, 7(1), 21-27.

National Pressure Ulcer Advisory Panel. (2007). Pressure ulcers prevalence, cost and risk assessment: consensus development conference statement. Decubitus, 2(2), 24-28.

Newnam, K. M., McGrath, J. M., Estes, T., Jallo, N., Salyer, J., & Bass, W. T. (2013). An integrative review of skin breakdown in the preterm infant associated with nasal continuous positive airway pressure. Journal of Obstetric, Gynecologic & Neonatal Nursing, 42(5), 508-516.

Newnam, K. M., McGrath, J. M., Salyer, J., Estes, T., Jallo, N., & Bass, W. T. (2015). A comparative effectiveness study of continuous positive airway pressure-related skin breakdown when using different nasal interfaces in the extremely low birth weight neonate. Applied Nursing Research, 28(1), 36-41.

Osman, M., Elsharkawy, A., & Abdel-Hady, H. (2015). Assessment of pain during application of nasal-continuous positive airway pressure and heated, humidified high-flow nasal cannulae in preterm infants. Journal of Perinatology, 35(4), 263-267.

Pillai Riddell, R., Racine, N., Turcotte, K., Uman, L., Horton, R., Ahola Kohut, S., ... & Lisi, D. (2011). Non-pharmacological management of infant and young child procedural pain: an abridged Cochrane review. (10): CD006275

Rezaei, P., Jafari-Mianaeib, S., Sadeghnia, A., & Heidari, Z. (2021). Protective Dressings, Injury, and Device Failure in Preterm Infants Receiving Nasal Continuous Positive Airway Pressure: A Randomized Controlled Trial. Advances in Skin & Wound Care, 34(9), 1-6.

Ribeiro, D. D. F. C., Barros, F. S., Fernandes, B. L., Nakato, A. M., & Nohama, P. (2020). Nasal prongs: risks, injuries incidence and preventive approaches associated with their use in newborns. Journal of Multidisciplinary Healthcare, 13(4), 527.

Ribeiro, D. D. F. C., Barros, F. S., Fernandes, B. L., Nakato, A. M., & Nohama, P. (2021). Incidence and Severity of Nasal Injuries in Preterm Infants Associated to Non-Invasive Ventilation Using Short Binasal Prong. Global Pediatric Health, 8, 2333794X211010459.

Robb, E., Jarman, B., Suntharalingam, G., Higgens, C., Tennant, R., & Elcock, K. (2010). Using care bundles to reduce in-hospital mortality: quantitative survey. BMJ, 340(c1234).

Shi, Y., Muniraman, H., Biniwale, M., & Ramanathan, R. (2020). A review on non-invasive respiratory support for management of respiratory distress in extremely preterm infants. Frontiers in pediatrics, 8, 270.

Sousa, N. F. C. D., Bonfim, S. D. F. S. F., Vasconcelos, M. G. L. D., Bezerra, J. L. D. O., Silva, D. V. C. D., & Leal, L. P. (2013). Prevalence of nasal septum injury in premature infants using nasal prongs. Revista da Escola de Enfermagem da USP, 47, 1285-1290.

Stevens, B., Johnston, C., Petryshen, P., & Taddio, A. (1996). Premature infant pain profile: development and initial validation. The Clinical journal of pain, 12(1), 13-22.

Sweet, D. G., Carnielli, V., Greisen, G., Hallman, M., Ozek, E., Plavka, R., ... & Halliday, H. L. (2013). European consensus guidelines on the management of neonatal respiratory distress syndrome in preterm infants-2013 update. Neonatology, 103(4), 353-368.

Tauzin, M., & Durrmeyer, X. (2019, August). Managing neonatal pain in the era of non-invasive respiratory support. In Seminars in Fetal and Neonatal Medicine. 24(4) p. 101004). WB Saunders.

Torres-Castro, C., Valle-Leal, J., Martínez-Limón, A. J., Lastra-Jiménez, Z., & Delgado-Bojórquez, L. C. (2016). Pulmonary complications associated with mechanical ventilation in neonates. Boletín Médico Del Hospital Infantil de México (English Edition), 73(5), 318-324.

Vitaliti, S. M., Costantino, G., Li Puma, L., Re, M. P., Vergara, B., & Pinello, G. (2012). Painful procedures in the NICU. The Journal of Maternal-Fetal & Neonatal Medicine, 25(4), 138-139.

Waskosky, A., & Huey, T. K. (2014). Quality improvement project: implementing guidelines supporting noninvasive respiratory management for premature infants. Neonatal network, 33(5), 245-254.

Xie, L. H. (2014). Hydrocolloid dressing in preventing nasal trauma secondary to nasal continuous positive airway pressure in preterm infants. World journal of emergency medicine, 5(3), 218-222.