J Afric Neonatal 2026;4: 112 – 120

ORIGINAL

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An integrative review of neonatal nasal injuries from nasal CPAP in low-resource settings

https://dx.doi.org/10.67210/afna.v4i3.1

Received: 28th April 2026
Accepted: 7th July 2026

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Abstract: Nasal continuous positive airway pressure (nCPAP) is a strongly recommended intervention for the care of premature neonates worldwide; however, it is often associated with a range of nasal injuries. Characteristics and prevention strategies of nCPAP associated injuries are not well characterized for low-resource settings. A literature search of Embase, MEDLINE, PubMed, and Google Scholar was conducted for peer-reviewed English-language studies published between January 1, 2013, and September 12, 2025. Search terms included combinations of "neonates," "CPAP," "non-invasive ventilation," and "nasal injury." Titles and abstracts were screened, and relevant data were extracted and synthesized. No formal risk-of-bias assessment was performed. Of the 97 manuscripts screened, 72 were relevant to the research question and therefore included in this review. The reported incidence of nasal injuries varied widely. Risk factors included improper interface sizing, prolonged therapy, and inadequate monitoring. Preventive strategies included correct interface application, protective barriers or lubricants, structured nursing bundles, frequent skin assessment, and staff training. Low-cost measures, such as proper prong sizing, skin monitoring, stabilization of the interface, and standardized protocols are feasible in low-resource settings. In conclusion, affordable, context-appropriate interventions may reduce nCPAP-related nasal injuries. Further research is needed to evaluate effectiveness and scalability in low-resource settings.

Introduction

Respiratory distress is one of the leading causes of neonatal mortality worldwide. Consequently, there is a critical need for global access to quality respiratory devices and care. Given the association between mechanical ventilation and subsequent chronic lung inflammation, there has been a growing shift toward less invasive methods of supporting ventilation. Nasal continuous positive airway pressure (nCPAP) has gained widespread use and is now regarded as a preferred method of respiratory support for premature neonates[1].

Treatment with nCPAP has many benefits, including reduced need for invasive ventilation, surfactant replacement, and supplemental oxygen[2]. However, nCPAP is also associated with nasal injuries that may range from simple erythema to destructive necrosis. These injuries can lead to pain, discomfort, and permanent disfigurement[3–5].

Implementation and integration of nCPAP in low-resource settings is difficult due to a lack of basic infrastructure, insufficient knowledge and skills, staff shortages, and cost, among other barriers[6–8]. Although there are no studies that compare the rates of nasal injuries in low-resource settings to those in high-resource settings, the many challenges in low-resource settings may place neonates at a higher risk of nasal injuries from nCPAP. In the author's work on training and implementation of a respiratory support package of care, inclusive of a novel nCPAP device (Vayu Global Health Innovations, Public Benefit Corporation, Medford, MA, USA) across more than 40 countries, there is little common understanding of best practices for the prevention and treatment of nasal injuries in low-resource settings.

This integrative review was undertaken to explore nCPAP-related nasal injuries in low-resource settings. The study's objective was to rigorously review the nCPAP-associated injury landscape, including their characteristics and classification, their incidence, associated risk factors, and typical onset. Additionally, recommendations for nasal injury prevention practices for low-resource settings are described.

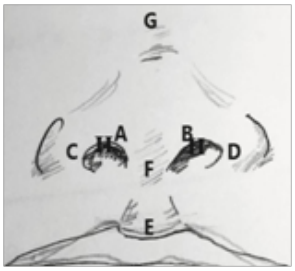
Methods

A literature search of Embase, MEDLINE, PubMed, and Google Scholar was conducted. The search strategy included both keywords and medical subheading terms in the following combinations: ("newborns" OR "neonates") AND (continuous positive airway pressure" OR "CPAP" OR "non-invasive ventilation" OR "NIV" OR "nasal cannula") AND ("nasal injury" OR "nasal trauma" OR "acquired nasal deformity").
Peer reviewed studies published in English between January 1, 2013, and September 12, 2025, were included. Reference lists, conference abstracts, and news articles were also reviewed. The titles and abstracts from 97 publications were screened for relevance, 72 of which were included in this review. No formal risk-of-bias analysis was performed.

Characteristics of nasal injuries

Nasal CPAP associated skin injuries are caused by pressure from the nasal interface. Pressure from the nasal interface reduces local blood flow and can cause tissue ischemia and progressive tissue destruction over time[4]. The severity of nasal injuries ranges from local erythema to full-thickness necrosis. The injuries can occur in various areas of the nose, including the columella, ala, and septum[9];

Fig 1: reproduced with permission, Zores *et al*[5].



While the phrase "nasal injury" is widely used across the literature, there is no unified definition of the term[9]. Nasal injuries associated with nCPAP use have been described extensively, primarily using terms such as redness, bleeding, ulceration, necrosis, excoriation, and permanent nasal disfigurement[5].

Severe nasal injuries such as columellar necrosis were described in several case reports and series[10–12]. The authors of one case report described the development of obstructing nasal synechiae in a premature neonate who was treated with nCPAP for 35 days, where binasal prongs were alternated with a nasal mask[13]. In another case report, pressure ulcers, bilateral alae defects, nasal tip and infratip lobule necrosis, and full thickness columellar necrosis were described[14]. In a prospective study, researchers found that nCPAP-related nasal injuries occurred most frequently at the columella, followed by the intranasal mucosa and the internal nostril orifice [3]. In a study that reviewed 33 years of nCPAP use and associated nasal injuries, authors described that long-term sequelae may include scarring, asymmetry, tip deviation and collapse, nasal airway obstruction, and permanent loss of tissue. The inferior third of the nose was affected in all patients with nasal injury[15].

Classification of nasal injuries

Fischer *et al*. described a three-stage classification system based on the US National Pressure Ulcer Advisory Panel[16,17]. The first stage is the mildest and presents as erythema that does not blanch under gentle pressure. In the second stage, the injury includes superficial ulceration and bleeding. The hallmark of the third stage is necrosis and permanent tissue loss[5,18,19]. Ribeiro *et al* employed this three-stage classification system but further distinguished external from internal injuries[4].

Several other authors used a four-stage system to classify nasal injuries. Grades 1-4 progress from septal hyperemia to superficial ulceration, to necrosis, to septal tissue loss[20,21]. Another system, the *Neonatal Skin Condition Score,* characterizes and scores injuries based on three elements: dryness, erythema, and rupture/injury of the skin[22,23]. Gökdoğan *et al*[24]. classified nasal injuries into two groups: nasal *skin* injury such as hyperemia and columellar necrosis due to pressure from the nasal interface, and nasal *mucosal* injury due to pressurized air [24].

Epidemiology, risk factors, and onset of nasal injury

Epidemiology and incidence of nCPAP-associated nasal injury

There is considerable variation in the reported incidence of nCPAP-associated nasal injuries in the scientific literature (Table 1). Comparing published studies is challenging due to the wide variability in the definitions and descriptions of nasal injuries. Injury definitions can range from mild local erythema to full septum necrosis.
Nasal injuries were reported in the literature as early as 1978 when authors of a case report described a premature infant with nCPAP-associated nasal septal necrosis and perforation[35]. In a report from St. George Hospital in London over a six-month period in 1995, seven out of thirty-five very low birth weight (VLBW) neonates treated with flow-driver CPAP sustained significant nasal injury[34].

Risk factors

Several risk factors contribute to nasal injuries associated with nCPAP use. Preterm infants are especially vulnerable because of their immature skin, reduced subcutaneous fat, and fewer stratum corneum layers of the skin[36]. Early gestational age, low birth weight, and prolonged exposure to nCPAP significantly increase the risk of nasal injuries[28,30–33,37,38]. Additional risk factors include inadequate training, poor professional practices, and substandard equipment. Proper monitoring of prong

placement and correct prong and hat sizing are frequent weaknesses in care. Insufficient humidification of the respiratory gases will lead to drier nasal mucosa and increase vulnerability to injury[4].

Onset and evolution of nasal injuries

Most nasal injuries develop within the first few days of nCPAP initiation[16,26,39]. In a retrospective study over five years in a neonatal intensive care unit (NICU) in Portugal, 135 neonates were treated with nCPAP. Nasal trauma was reported in 65%, and the median time of onset was four days[29]. In a 21-month study from the NICU at the University Hospital of Strasbourg, 64 out of 276 newborns treated with nCPAP had nasal injuries. More than half of those with moderate or severe injuries had significant persistent defects after one year [3].

Potential consequences of nasal injuries

When nasal skin breaks down, neonates become more vulnerable to infection. This elevated risk of infection increases the potential for sepsis, prolonged hospital stays, adverse neurodevelopment, and death. Prolonged hospital stays may lead to significant emotional stress for families and may impose considerable financial burdens[40].

Since nasal injuries may progress to permanent disfigurement and significant other untoward morbidities, patients may suffer from a lifetime of associated health, social, and personal identity challenges[40].

Strategies for prevention of nasal injuries

Multiple researchers examined potential interventions to reduce the likelihood of developing nCPAP-associated nasal injuries[38,41]. Some of these interventions focused on the interface and use of barriers or lubricants, while others addressed nursing practices and organizational structures.

Interface

The interface includes nasal prongs or masks, breathing tubes, and anything used to secure the components to a neonate. The interface must be securely positioned to avoid exerting pressure on the infant's immature skin [13,19]. Selection of appropriate size prongs and hats is critical, as an interface that is loose may cause friction related injuries, and an interface that is too tight will harm the infant's skin from constant pressure [19,30,42,43].
Nasal prongs and nasal masks were evaluated in several studies for their potential role in causing nasal injuries. Some investigators reported that nasal masks exert less pressure on the more delicate parts of the nose, such as the septum and columella, and therefore result in a decreased risk of nasal injuries[44–47]. Other investigators disagreed and found no significant differences between the two, arguing that all nasal interfaces contribute to nasal injuries, albeit at different pressure points [48–50]. Some researchers suggest that alternating nasal prongs and a nasal mask every 4-12 hours might help preserve healthy nasal skin[51–53].

Nasal CPAP guidelines recommend that nasal prongs should only be used once. When reprocessed and reused across different patients, prongs stiffen and increase the risk of nasal injury. Despite this, reuse of nasal prongs in low-resource settings is common since access to disposable prongs is limited[4,19,31,42]. Nasal prongs must be appropriately curved to follow natural anatomical lines and sit securely and comfortably in the nares. To avoid excessive skin pressure there should be a space of approximately 2mm between the base of the nasal prongs and the columella of the nose[19].

Barriers and Lubrication

The nose should be cleaned and dried before placing an infant on nCPAP[54]. A barrier should be established between the nasal prongs, and the nasal septum and skin. Protective dressings, barrier creams, foam barriers, and hydrocolloid gels can significantly reduce the risk of nasal injury[25,55–60]. Hydrocolloid dressings such as Neoseal™ were shown to decrease the risk of nasal injury, especially in patients treated with nCPAP for more than 5 days, with a gestational age of less than 30 weeks, or with a weight of 3000 g or less[14,60,61]. Application of a lubricant or saline to the prongs prior to insertion may decrease the risk of injury[62]. Authors of one case report suggested using nasal suction catheters to clear potentially irritating secretions from the upper airways. However, nasal suction itself may damage nasal tissue, narrow the nasal passage, and cause obstruction[13].

Nursing surveillance and positioning

Quality neonatal nursing care is essential for good outcomes. Frequent skin inspections can prevent nasal injuries and detect injuries early enough to prevent irreversible damage[19,57]. Circular massage of the nose every two to four hours, or during an exchange of prongs to mask, may reduce the risk of nasal injuries[16,19,38].

Prone positioning of a neonate with the hand tucked under the chin may help maintain nCPAP pressure and decrease movement of the prongs and mask[63]. However, in a randomized crossover study, researchers found a significantly higher frequency of prong displacement in the prone position. This may be related to involuntary cervical movement caused by the pressure of the interface on the face[64]. Comfort measures such as swaddling, positioning aids, pacifiers, kangaroo care, parental presence, and minimal noise or light stimulation may help decrease movement of the neonate and decrease the risk of nasal injury[63].

Organizational interventions

Several authors described the importance of improving

the knowledge, attitude, skill, and behavior of the care team. Implementation of nasal care and injury prevention protocols with frequent training and mentoring sessions were successful in several settings [20,25,27,54,57,65,66]. In a randomized controlled trial in Iran, Jabraeili *et al*. found significantly lower nasal injury scores in preterm infants that received nCPAP treatment in a protocolized care group as compared to a routine care group[67]. Moreover, a significant reduction in pressure injury scores with implementation of a care checklist was reported in a quasi-experimental study from a NICU in Turkey[68].

The frequency of neonatal nasal injuries significantly decreases when care is provided by nurses trained on proper application of nasal masks and prongs[27]. In their study from South India, Naha *et. al* found that neonates had lower rates of nasal injuries when cared for by nurses trained on a standardized bundle of care that included guidance on patient and interface positioning, suctioning, nasal massages, and interface breaks[43]. Mohamed *et al* demonstrated similar findings in Egypt after implementation of a nursing bundle of care that included the use of dressings, frequent skin monitoring, and a protocol on application of the interface[69]. Similarly, researchers in Taiwan reported more rapid application of nCPAP and significantly fewer nasal injuries after the implementation of a standardized nursing protocol[65].

Treatment options for nasal injuries (NIs)

Mild nasal injuries presenting as non-blanchable redness should be managed by repositioning the respiratory interface to relieve sustained pressure[51-53]. Skin protection includes hydrocolloid or silicone barrier dressings, gentle circular massage with saline or protective ointments to promote tissue recovery, and use of moisturizing or barrier gels[25,55-60]. Newborns with severe nasal injuries associated with nCPAP may need reconstructive surgery including skin grafts and flaps[15,70,71]. Some children may require several operations[15]. There are few non-surgical interventions, however the authors of a case report described regeneration of nasal tissue after the application of cord blood platelet gel[72].

Table 2: Recommendations for prevention of nasal injuries in low-resource settings

In Initiation of nCPAP Therapy
Ensure nose is clean and dry [54]
Select appropriate nasal prong size Prongs must fill each nostril completely[19,30,42,43]
If the nCPAP interface includes headgear/hats, select appropriate headgear size and apply with proper fit[19,30,42,43]
Lubricate nasal prongs with a lubricant or gauze soaked in saline[62]
Apply a protective barrier to the philtrum and nose using Velcro moustaches, non-irritant barrier creams, petroleum jelly, or hydrocolloid dressings[25,55-60]
Elevate head to 30 degrees (this can be achieved by placing a small towel under the patient's head) and gently place nasal prongs downwards and inwards into the patient's nares - do not exert excessive pressure[43]
If nasal skin is blanched thirty seconds after prong insertion, the prongs are too large and must be exchanged for a smaller size[19,29,55]
Maintain a distance of 2-3 mm between the bridge of the nasal prongs and the nasal columella[19,65]. Consider placing a cotton pad or gauze between the base of the nasal prongs and the columella.
Ensure patient interface is stable, fixed, and midline before initiating nCPAP therapy[27,66]
Skin Monitoring While on nCPAP Therapy Perform the following every 4 hours:
Inspect the skin and nose (the nose tip, nares, philtrum, and septum) and assess for signs of nasal injury[19,57]
Ensure the nose remains dry and clean[54]
Massage the nose gently with circular movements[16,19,38]
Clear secretions but only suction the nose when necessary[13]
Ensure a distance of 2-3 mm between the bridge of the nasal prongs and the nasal columella[19,65]
Injury Prevention Quality Practice
Create and implement a standardized protocol for frequent monitoring and injury prevention[20,25,27,54,57,65]
Conduct audits andprovide structured feedback[20,27,54,57,65,43]
Train and frequently refresh staff on recommendations[19,20,25,27,57,65]

Table 1: Incidence of nCPAP-associated nasal injury. Listed in chronological descending order of publication.

Author, Year	Study Design	Study Location	Sample Size	Mean Gestational Age (weeks)	Gestational Age Range (weeks)	Mean Birth weight (g)	Birth weight Range (g)	Form of Ventilation	Nasal Interface	Incidence of Nasal Injury
Broom M *et al,*[25]	Prospective descriptive quality improvement – phase I	Canberra, Australia	288	> 32 weeks group: 34.4 ≤ 32 weeks group: 29.2	NS	> 32 weeks group: 2478 ≤ 32 weeks group: 1369	NS	nCPAP	Binasal prongs, prior to introducing nasal injury care plan	19%
Broom M *et al,*[25]	Prospective descriptive quality improvement – phase II	Canberra, Australia	199	> 32 weeks group: 35.5 ≤ 32 weeks group: 29.5	NS	> 32 weeks group: 2684 ≤ 32 weeks group: 1374	NS	nCPAP	Binasal prongs, after introducing nasal injury care plan	13.5%
Broom M *et al,*[25]	Prospective descriptive quality improvement – phase III	Canberra, Australia	198	NS	NS	NS	NS	nCPAP	Binasal prongs, ongoing nasal injury care plan	9.5%
Grebinski A et al,[20]	Exploratory retrospective descriptive	Cascavel, Paraná, southern Brazil	116	NS	26.9-33.1	NS	700-1920	NIV	Binasal prongs	19%
Pascual A & Wielenga J,[26]	Prospective observational	Amsterdam, the Netherlands	118	29.3	NS	1222	NS	nCPAP	Nasal mask and binasal prongs	90.7%
Wu Y *et al*,[27]	Prospective observational	Wenzhou, China	127	30.25	< 37	1502	NS	nCPAP	Nasal mask and binasal prongs	27.6%
Dai T *et al*, [28]	Prospective observational	Xiamen, southeastern China	429	32.71	NS	1887	NS	nCPAP	Binasal prongs	34.7%
Guimarães A *et al,* [29]	Retrospective cohort	Porto, Portugal	135	28	26-30	1072	833-1311	nCPAP	Binasal prongs	65%
Khan J *et al*,[21]	Secondary analysis of a randomized controlled trial	India	90	29.9	< 34	1227	NS	Bubble nCPAP	Binasal prongs	74.4%
Khan J et al,[21]	Secondary analysis of a randomized controlled trial	India	80	29.9	< 34	1227	NS	Jet nCPAP	Binasal prongs	45%
Hameed N [et al, 30]	Prospective observational	Baghdad, Iraq	210	33	NS	2044	NS	nCPAP	Binasal prongs	100%
Bonfim S *et al*,[31]	Analytic and prospective cohort	Recife, Pernambuco, northeastern Brazil	70	NS	NS	NS	NS	NIV	Binasal prongs	62.9%
Primo C *et al*,[32]	Retrospective observational	Vitória, Espírito Santo, Brazil	117	NS	NS	NS	NS	nCPAP	NS	19.7%
Cabral de Sousa N *et al*,[33]	Cross-sectional	Recife, Pernambuco, northeastern Brazil	47	NS	NS	NS	NS	NIV	Binasal prongs	68.1%
Fischer C *et al*,[16]	Prospective observational	Lausanne, Switzerland	989	34	NS	2143	NS	nCPAP	Nasal mask and binasal prongs (alternating every 4-6 hours)	42.5%
Robertson N *et al*,[34]	Observational	London, the United Kingdom	35	NS	NS	NS	NS	Flow driver nCPAP	Binasal prongs	20%

*NS = non-specified
*NIV = non-invasive ventilation (includes nCPAP)

Recommendations for nasal injury prevention in resource-limited settings

The key to prevent nasal injuries is to avoid excessive pressure on the nares. The recommendations in table 2 originate from best practices described in the literature and those shared by senior neonatal healthcare providers and respiratory therapists in resource-limited settings.

Limitations

Since there was a paucity of relevant research from low-resource regions the literature search was more broadly inclusive of all settings. The authors acknowledge that the varying ecosystems within which many of the included studies were conducted may have affected the studies' findings and conclusions, however the root causes and emergent prevention measures are likely similar across settings. As an integrative review this study was not able to objectively compare weight-based success rates of various nasal injury prevention methods. However, we believe that our approach to examination and review of the heterogeneous literature allowed for a better understanding of the overall landscape and emergence of practical recommendations.

Conclusion

This integrative review shed light on challenges faced in low-resource settings and presented low-cost and feasible methods of nasal injury prevention. More studies are needed to explore the effectiveness and feasibility of nasal injury prevention techniques in low-resource settings.

Declarations: TFB is the founder of Vayu Global Health Innovations, a public benefit company that has signed global access commitments with the Gates Foundation, UNITAID, the World Health Organization, and Grand Challenges Canada. The Vayu Global Health Foundation is a 501(c)^3 registered non-profit focused on training, programs, and research to improve the lives of pregnant women, children under 5, and neonates worldwide.
Conflicts of interest: None

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