F&P **Optiflow** Junior **2**

Nasal high flow (NHF) in pediatric care

starting at flow rates of 2 L/kg/min can:

- ↓ ED boarders[1-3]
- ↓ intubations[1-4]
- ↓ patient escalation[3]
- ✓ cost savings[2,5]
- ↓ length of stay[6]

1. Wing et al. Pediatric Emergency Care 28, 1117–1123 (2012).
2. Mayfield et al. J Pediatric Child Health 50, 373–378 (2014).
3. Franklin et al. N Engl J Med 378, 1121–1131 (2018).
4. Schibler et al. Intensive Care Med 37, 847–852 (2011).
5. Willer et al. Hosp Pediatr 11, 891–895 (2021).
6. Ramnarayan et al. JAMA 328(2), 162–172 (2022).

www.fphcare.com

Fisher & Paykel HEALTHCARE

Mechanisms of action

NHF definition:[1-3]

Nasal high flow (NHF) is a mode of noninvasive respiratory support that delivers high flows of heated and humidified blended air and oxygen through an unsealed nasal interface.

NHF benefits

NHF offers a range of benefits compared with standard oxygen therapy, and there are several mechanisms of action associated with this therapy, including airway hydration and reduction of anatomical dead space.

1. Wilkinson D et al. Cochrane Database Sys Rev (2016); 2. Collins CL et al. J Pediatr 162(5):949–954 (2013); 3. Franklin D et al. N Engl J Med 1121-1131 (2018).

4. de Klerk A. Adv Neonatal Care 8, 98-106 (2008); 5. Saslow J et al. J Perinatol 26, 476-480 (2006); 6. Milési C et al. Intensive Care Med 39, 1088-1094 (2013); 7. Hough J et al. Pediatr Crit Care Med 15, e214-219 (2014); 8. Sinha I et al. Chest 148, 810-823 (2015); 9. Collins CL et al. Eur J Pediatr 173, 181-186 (2014); 10. Roberts C et al. N Engl J Med 375, 1142-1151 (2016).

Increasing evidence in the use of NHF for infants and children

A systematic search of available literature shows there are more than 220 peer-reviewed papers investigating the use of NHF therapy in infants and children.

Of these, 31 are randomized controlled trials (RCTs) – they compared NHF with standard oxygen therapy, continuous positive airway pressure (CPAP) and alternative treatments.

31 RCTs

- NHF vs. standard oxygen therapy
- NHF vs. CPAP
- NHF vs. alternative therapies

12 systematic reviews

2010
McKiernan et al.[1]
Australia

The use of NHF in the PICU for infants with bronchiolitis was associated with a decreased need for intubation.

2011
Schibler et al.[2]
Australia

Retrospective review showing an increased use of NHF was associated with a reduced need for intubation in children with bronchiolitis.

2012
Wing et al.[3]
USA

Retrospective review showing the early use of NHF in the ED reduced the need for intubation in the PICU.

2013
Milési et al.[4]
France

Physiological study indicating that a flow of approximately 2 L/kg/min is required to improve work of breathing in bronchiolitis patients.

2014
Rubin et al.[5]
USA

Physiological study confirming that increasing flow rate was associated with decreased effort of breathing in children post extubation.

2014
Testa et al.[6]
Italy

RCT showing NHF improved PaO_2 but had no impact on $PaCO_2$ in pediatric cardiac patients.

2014
Mayfield et al.[7]
Australia

Pilot RCT showing that improvements to heart rate and respiratory rate within 1 hour are predictors of NHF therapy success outside the PICU.

2014
Pham et al.[8]
Australia

Physiological study showing the use of 2 L/kg/min in bronchiolitic and cardiac infants reduced the work of breathing.

2017
Milési et al.[9]
France

RCT showing NHF did not have a failure rate similar to that of nCPAP in the PICU.

2017
Kepreotes et al.[10]
Australia

RCT showing NHF at 1 L/kg/min did not significantly reduce time on oxygen in infants with bronchiolitis compared with standard oxygen therapy.

2018
Franklin et al.[11]
Australia, New Zealand

Largest RCT including > 1400 infants with bronchiolitis in non-ICU settings, showing therapy failure rate was lower in NHF compared with standard oxygen therapy.

2022
Ramnarayan et al.[12]
UK

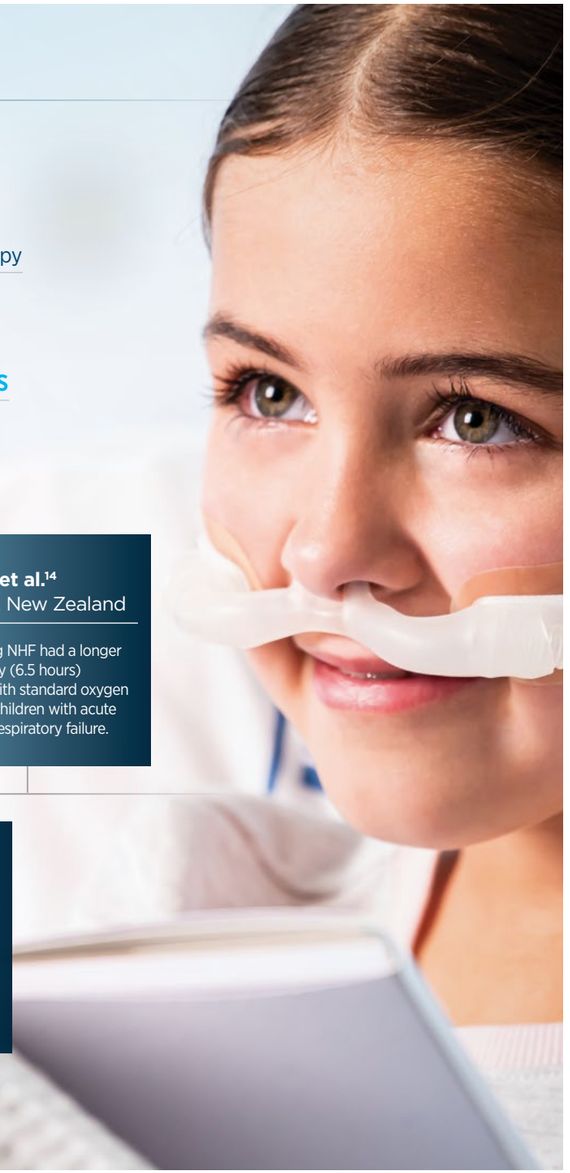
RCT showing NHF did not meet noninferiority criteria compared with CPAP in the time to liberation from respiratory support post extubation.

2022
Ramnarayan et al.[13]
UK

RCT showing NHF met the noninferiority criteria when compared with CPAP for time to liberation of respiratory as first-line support.

2022
Franklin et al.[14]
Australia, New Zealand

RCT showing NHF had a longer length of stay (6.5 hours) compared with standard oxygen therapy for children with acute hypoxemic respiratory failure.



1. McKiernan et al. J Pediatr (2010).
2. Schibler et al. Intensive Care Med (2011).
3. Wing et al. Pediatr Emerg Care (2012).
4. Milési et al. Intensive Care Med (2013).
5. Rubin et al. Pediatr Crit Care Med (2014).
6. Testa et al. Interact Cardiovasc Thorac Surg (2014).
7. Mayfield et al. J Paediatr Child Health (2014).
8. Pham et al. Pediatr Pulmonol (2015).
9. Milési et al. Intensive Care Med (2017).
10. Kepreotes et al. Lancet (2017).
11. Franklin et al. N Engl J Med (2018).
12. Ramnarayan et al. JAMA (2022).
13. Ramnarayan et al. JAMA (2022).
14. Franklin et al. JAMA (2022).

Reduce ED boarders

Schibler et al. 2011.
Intensive Care Medicine[1]

Mayfield et al. 2014.
Journal of Paediatrics and Child Health[2]

ED PICU FLOOR

Within **60** minutes

IMPROVEMENT IN:

- Respiratory rate (RR)
- Heart rate (HR)
- Work of breathing

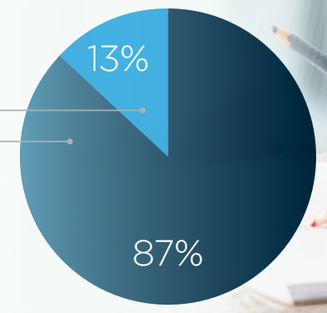
- Nonresponders requiring PICU admission can be identified within the first hour of NHF treatment by monitoring HR and RR.[1,2]
- Infants receiving NHF at 2 L/kg/min were 4 times less likely to be admitted to PICU than those receiving standard O_2.[2]

Note: Standard O_2 = 100% O_2;
NHF at 2 L/kg/min = Total flow/kg/min; FiO_2 titrated

Responders to NHF (Mayfield 2014)

13% of patients did not respond to NHF and were admitted to PICU.

87% of patients responded to NHF and remained on the floor when using 2 L/kg/min vs. standard O_2.[2]

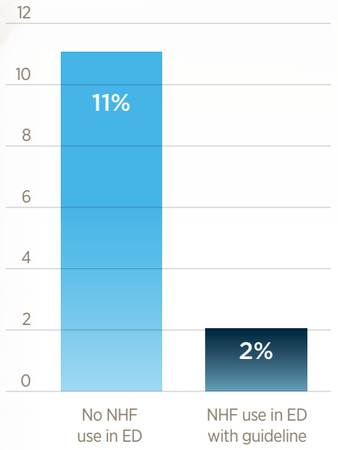


1. Schibler et al. Intensive Care Med 37, 847–852 (2011); 2. Mayfield et al. J Pediatric Child Health 50, 373–378 (2014).

Reduce intubations

Wing et al. 2012.
Pediatric Emergency Care[1]

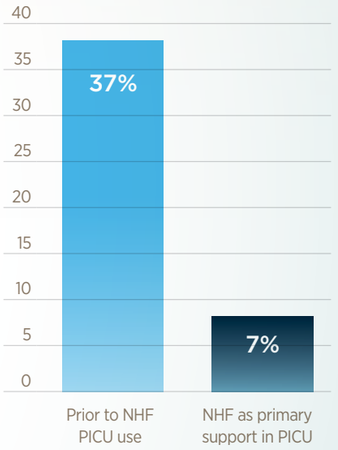
ED



- Implementation of an NHF guideline was associated with a reduced intubation rate in the ED.

Schibler et al. 2011.
Intensive Care Medicine[2]

PICU



- Increasing use of NHF led to reduced intubation rates in the PICU.

1. Wing et al. Pediatric Emergency Care 28, 1117–1123 (2012); 2. Schibler et al. Intensive Care Med 37, 847–852 (2011).

Reduce patient escalation

Franklin et al. 2018.
The New England Journal of Medicine[1]

1,472 patients
(< 12 months)
with bronchiolitis

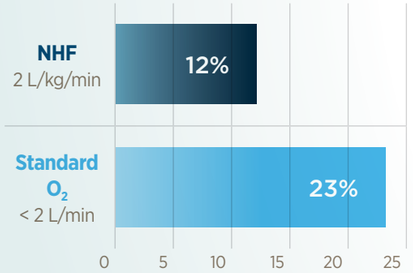
17 ED and floors

Primary outcome

- **Patients receiving NHF at 2 L/kg/min are half as likely to fail vs. standard O_2 < 2 L/min.**
- **All patients who failed standard O_2 received rescue NHF.**
  – 61% of them responded to NHF and avoided PICU.

Note: Standard O_2 = 100% O_2. NHF at 2 L/kg/min = Total flow/kg/min; FiO_2 titrated

Therapy failure



1 in 9 patients met therapy failure on NHF

1 in 4 patients met therapy failure on standard O_2

Those who received NHF had significantly lower rates of escalation of care due to therapy failure than those receiving standard O_2 ($p < 0.001$).[1]

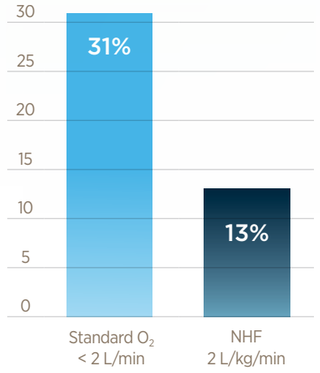
9/17
hospitals in
PARIS 1 did not
have a PICU

1. Franklin, et al. N Engl J Med. 378, 1121–1131 (2018).

Cost effectiveness of standardized NHF in the ED/floor

Introducing NHF in the ED

Mayfield et al. 2014[1]
Journal of Paediatrics and Child Health



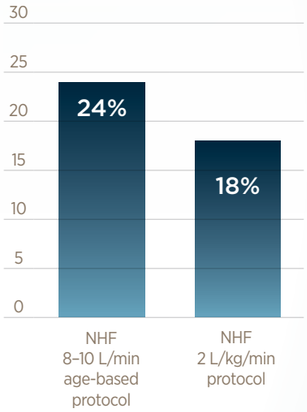
New NHF users in the ED

- PICU admissions reduced by 18%.
- Estimated US$850K savings per year by avoiding PICU (for a 19-bed PICU).

Standard O_2 = 100% O_2
NHF at 2 L/kg/min = Total flow/kg/min; FiO_2 titrated.

Age-based vs. weight-based NHF

Willer et al. 2021[2]
Hospital Pediatrics

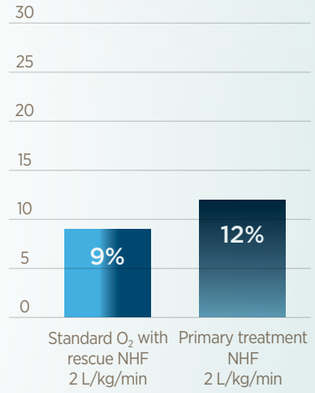


NHF users, refining protocols

- PICU admissions reduced by 6.2%.
- US$661 savings per bronchiolitis patient by avoiding PICU.

Primary NHF vs. early rescue NHF

Vijay et al. 2020[3]
Archives of Disease in Childhood



Experienced NHF user, hospital wide

- No statistically significant difference in PICU admissions due to use of rescue NHF.
- Cost neutral.

Note: Cost analysis of the PARIS 1 study.[4]

1. Mayfield et al. J Pediatric Child Health 50, 373–378 (2014); 2. Willer et al. Hosp Pediatr 11, 891–895 (2021); 3. Vijay et al. Arch Dis Child 105, 975–980 (2020); 4. Franklin et al. N Engl J Med 378, 1121–1131 (2018).

Reduce length of stay and sedation

Ramnarayan et al. 2022.
JAMA[1] *"STEP UP"*

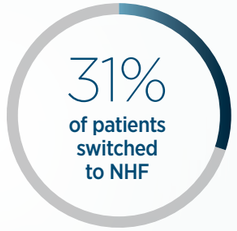
573 patients, 0 to 15 years
(median age: 3 months)

22/28 PICUs in the UK

Primary outcome

NHF as primary treatment was noninferior to CPAP for time on respiratory support.

Therapy failure was less likely in the NHF group compared with the CPAP group.



Predominantly due to discomfort

Predominantly due to clinical deterioration

Of the secondary outcomes, the NHF group had significantly:

9.3%
lower use of sedation
NHF 27.7% vs. CPAP 37.0%

3.1
less days in PICU*

7.6
less days in hospital*

Fewer occurrences of nasal trauma
NHF 2.0% vs. CPAP 6.5%

* Adjusted for prebaseline characteristics
1. Ramnarayan et al. JAMA 328(2), 162–172 (2022).

What affects patient throughput?

Franklin et al. 2023.
JAMA[1]

1,517 patients, 1 to 5 years with acute hypoxemic respiratory failure

14 ED and floors

Primary outcome

Hospital length of stay was longer in the NHF group compared with the standard oxygen therapy (SOT) group (6.5 hours, $p < 0.001$).

- All patients who failed standard O_2 received rescue NHF.

Patients receiving NHF may have been unnecessarily escalated to an on-site PICU because of the perception that they were sicker.

Points of interest

The NHF group had higher PICU admissions. However, 88% of the NHF group remained on NHF and did not require therapy escalation.

NHF 12.5% vs. SOT 6.9%

Escalation of care in non-PICU hospitals was similar.

NHF 2.3% vs. SOT 2.2%

1. Franklin et al. JAMA 329(3), 224–234 (2023).

Starting flow rates and weaning strategies

Starting flow rate

- 2 L/kg/min for patients up to 15 kg in weight has been shown to produce a rapid improvement in respiratory distress, and a reduced need for escalation of therapy.
- Weight-banding flow rates for > 15 kg have been protocolized by the PARIS 2[1] and FIRST-ABC[2] research groups.

Weight (kg)	≤ 15	16 – 30	31 – 50	> 50
Starting flow rate	2 L/min/kg	35 L/min	40 L/min	50 L/min

Weaning off NHF therapy

PARIS (ED)[1]

Once stable, infants were weaned to 21% FiO_2, with no changes to set flow rate.

Stopping therapy

NHF therapy was stopped after 1 hour.

OR

FIRST-ABC (PICU)[2]

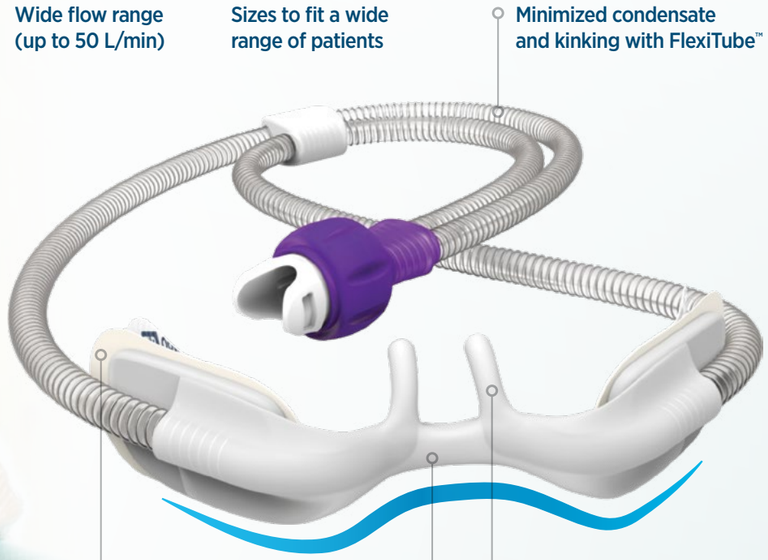
When FiO_2 was ≤ 0.40 patients were changed to receive weaning flow rates based on the patient.

Stopping therapy

When FiO_2 < 30% and/or mild respiratory distress, NHF was stopped.

1. Franklin et al. JAMA 329, 224–234 (2023); 2. Ramnarayan et al. JAMA 328, 162–172 (2022).

Optiflow Junior 2 interface product features



F&P Airvo™ 3 Optiflow System

Compatible with AirSpiral™ circuits and Optiflow Junior 2

HPO

High pressure oxygen

Large touch screen

Integrated battery

Interface size and flow rates

F&P Airvo 3

M

Weight (kg)*	1	1.5	8	10
Correlated age**	28 wkGA	31 wkGA	6.6 mo	15.4 mo
Maximum flow rate	7 L/min			

L

Weight (kg)*	3	3.5	18	20
Correlated age**	37.5 wkGA	40 wkGA	4.9 yr	5.6 yr
Maximum flow rate	20 L/min			

XL

Weight (kg)*	5	7	25	30
Correlated age**	47.5 wkGA	4.7 mo	7.6 yr	9.5 yr
Maximum flow rate	25 L/min			

XXL

Weight (kg)*	8	12.5	30	40
Correlated age**	6.4 mo	2.2 yr	9.5 yr	12 yr
Maximum flow rate	50 L/min			

F&P Airvo 2

wkGA = weeks of gestation; mo = months; yr = years. * Weight data is based on F&P product validation studies.
** Age data is a correlation to weight data based on a combination of Fenton, WHO and CDC growth charts.

F&P Optiflow Junior 2

Cerpa F, Cáceres D, Romero-Dapueto C, Giugliano-Jaramillo C, Pérez R, Budini H, Hidalgo V, Gutiérrez T, Molina J, Keymer J. Suppl 2: M5: Humidification on Ventilated Patients: Heated Humidifications or Heat and Moisture Exchangers? The Open Respiratory Medicine Journal. 2015;9:104.

Collins CL, Barfield C, Horne RS, Davis PG. 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. 2014 Feb;173:181–6.

Collins CL, Holberton JR, Barfield C, Davis PG. 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. 2013 May 1;162(5):949–54.

de Klerk A. Humidified high-flow nasal cannula: is it the new and improved CPAP? Advances in Neonatal Care. 2008 Apr 1;8(2):98–106.

Franklin D, Babl FE, George S, Oakley E, Borland ML, Neutze J, Acworth J, Craig S, Jones M, Gannon B, Shellshear D. Effect of early high-flow nasal oxygen vs standard oxygen therapy on length of hospital stay in hospitalized children with acute hypoxemic respiratory failure: the PARIS-2 Randomized Clinical Trial. JAMA. 2023 Jan 17;329(3):224–34.

Franklin D, Babl FE, Schlapbach LJ, Oakley E, Craig S, Neutze J, Furyk J, Fraser JF, Jones M, Whitty JA, Dalziel SR. A randomized trial of high-flow oxygen therapy in infants with bronchiolitis. New England Journal of Medicine. 2018 Mar 22;378(12):1121–31.

Gc VS, Franklin D, Whitty JA, Dalziel SR, Babl FE, Schlapbach LJ, Fraser JF, Craig S, Neutze J, Oakley E, Schibler A. First-line oxygen therapy with high-flow in bronchiolitis is not cost saving for the health service. Archives of Disease in Childhood. 2020 Oct 1;105(10):975–80.

Hough JL, Pham TM, Schibler A. Physiologic effect of high-flow nasal cannula in infants with bronchiolitis. Pediatric Critical Care Medicine. 2014 Jun 1;15(5):e214–9.

Kepreotes E et al. High-flow warm humidified oxygen versus standard low-flow nasal cannula oxygen for moderate bronchiolitis (HFWHO RCT): an open, phase 4, randomised controlled trial. The Lancet. 2017; 389, 930-39.

McKiernan C, Chua L, Visintainer P, Allen H. High-flow nasal cannulae therapy in infants with bronchiolitis. The Journal of Pediatrics. 2010;156(4), 634-38.

Mayfield S, Bogossian F, O'Malley L, Schibler A. High-flow nasal cannula oxygen therapy for infants with bronchiolitis: pilot study. Journal of Paediatrics and Child Health. 2014 May;50(5):373–8.

Milési C, Baleine J, Matecki S, Durand S, Combes C, Novais AR, Cambonie G. Is treatment with a high flow nasal cannula effective in acute viral bronchiolitis? A physiologic study. Intensive Care Med. 2013 Jun;39(6):1088-94.

Milési C, Essouri S, Pouyau R, Liet JM, Afanetti M, Portefaix A, Baleine J, Durand S, Combes C, Douillard A, Cambonie G; Groupe Francophone de Réanimation et d'Urgences Pédiatriques (GFRUP). High flow nasal cannula (HFNC) versus nasal continuous positive airway pressure (nCPAP) for the initial respiratory management of acute viral bronchiolitis in young infants: a multicenter randomized controlled trial (TRAMONTANE study). Intensive Care Med. 2017 Feb;43(2):209-16.

Ramnarayan P, Richards-Belle A, Drikite L, Saull M, Orzechowska I, Darnell R, Sadique Z, Lester J, Morris KP, Tume LN, Davis PJ. Effect of high-flow nasal cannula therapy vs continuous positive airway pressure therapy on liberation from respiratory support in acutely ill children admitted to pediatric critical care units: a randomized clinical trial. JAMA. 2022 Jul 12;328(2):162–72.

Ramnarayan P, Richards-Belle A, Drikite L, Saull M, Orzechowska I, Darnell R, Sadique Z, Lester J, Morris KP, Tume LN, Davis PJ. Effect of high-flow nasal cannula therapy vs continuous positive airway pressure following extubation on liberation from respiratory support in critically ill children: a randomized clinical trial. JAMA. 2022 Apr 26;327(16):1555–65.

Richards-Belle A, Davis P, Drikite L et al. FIRST-line Support for Assistance in Breathing in Children (FIRST-ABC): a master protocol of two randomised trials to evaluate the non-inferiority of high-flow nasal cannula (HFNC) versus continuous positive airway pressure (CPAP) for non-invasive respiratory support in paediatric critical care. BMJ Open. 2020;10:e038002.

Roberts CT, Owen LS, Manley BJ, Frøisland DH, Donath SM, Dalziel KM, Pritchard MA, Cartwright DW, Collins CL, Malhotra A, Davis PG. Nasal high-flow therapy for primary respiratory support in preterm infants. New England Journal of Medicine. 2016 Sep 22;375(12):1142–51.

Rubin S et al. Effort of breathing in children receiving high-flow nasal cannula. Pediatr Crit Care Med. 2014;15, 1-6.

Saslow JG, Aghai ZH, Nakhla TA, Hart JJ, Lawrysh R, Stahl GE, Pyon KH. Work of breathing using high-flow nasal cannula in preterm infants. Journal of Perinatology. 2006 Aug;26(8):476–80.

Schibler A, Pham TM, Dunster KR, Foster K, Barlow A, Gibbons K, Hough JL. Reduced intubation rates for infants after introduction of high-flow nasal prong oxygen delivery. Intensive Care Medicine. 2011 May;37:847–52.

Sinha IP, McBride AK, Smith R, Fernandes RM. CPAP and high-flow nasal cannula oxygen in bronchiolitis. Chest. 2015 Sep 1;148(3):810–23.

Testa G et al. Comparative evaluation of high-flow nasal cannula and conventional oxygen therapy in paediatric cardiac surgical patients: a randomized controlled trial. Interact Cardiovasc Thorac Surg. 2014;19: 456-61.

Wilkinson D, Andersen C, O'Donnell CP, De Paoli AG, Manley BJ. High flow nasal cannula for respiratory support in preterm infants. Cochrane Database of Systematic Reviews. 2016 (2).

Willer RJ, Johnson MD, Cipriano FA, Stone BL, Nkoy FL, Chaulk DC, Knochel ML, Kawai CK, Neiswender KL, Coon ER. Implementation of a weight-based high-flow nasal cannula protocol for children with bronchiolitis. Hospital Pediatrics. 2021 Aug 1;11(8):891–5.

Wing R, James C, Maranda LS, Armsby CC. Use of high-flow nasal cannula support in the emergency department reduces the need for intubation in pediatric acute respiratory insufficiency. Pediatric Emergency Care. 2012 Nov 1;28(11):1117–23.

Yoder BA, Stoddard RA, Li M, King J, Dirnberger DR, Abbasi S. Heated, humidified high-flow nasal cannula versus nasal CPAP for respiratory support in neonates. Pediatrics. 2013 May 1;131(5):e1482–90.