RESEARCH ARTICLE

The Appropriate Use of High-Flow Nasal Cannula in Bronchiolitis: A Delphi Approach

Clea D. Harris, MD,[1,2] Jennifer D. Treasure, MD, MSc,[3,4] Kimberly Albanowski, MHS-MA,[5] Matthew J. Lipshaw, MD, MSc,[3,6] Christopher P. Bonafide, MD, MSCEe,[5,7] Alan R. Schroeder, MD,[8] Michelle Noelck, MD,[9] Courtney Byrd, MD,[10] Erika L. Stalets, MD, MSc,[3,11] Rachel Cane, MD, PhD,[1,2,12] Kelly Menachof, MD,[13] Amanda C. Schondelmeyer, MD, MSc[3,4,14]

ABSTRACT

OBJECTIVES: There is considerable practice variation nationally for using high-flow nasal cannula (HFNC) to treat hospitalized children with bronchiolitis, despite an abundance of literature supporting specific practices. We developed recommendations for using HFNC based on available evidence and expert opinion.

METHODS: Following the Research and Development (RAND)/University of California, Los Angeles Appropriateness Method, we conducted an exhaustive literature search for studies regarding the use of HFNC in bronchiolitis and drafted proposed use recommendations based on these findings. We convened an expert panel composed of nominees from national professional organizations with a range of professions (nursing, respiratory therapy, medicine) and clinical expertise (intensive care, emergency medicine, hospital-based care). Panelists rated recommendations for appropriateness and necessity in 3 sequential rating sessions and a moderated meeting.

RESULTS: The 15-member panel evaluated 60 recommendations for the initiation, reassessment, escalation, and de-escalation of HFNC in bronchiolitis. The panel reached agreement on the appropriateness of HFNC for 52 of 60 recommendations and on necessity for 46 of 52. The panel agreed with practices that may curtail HFNC use, including initiating HFNC only for refractory hypoxemia or impending respiratory failure, initiating HFNC at flow rates of 1.5 to 2 L/kg/min, and discontinuing HFNC once a patient is stable on fraction of inspired oxygen of 0.21 for 1-4 hours.

CONCLUSIONS: A national expert panel agreed on the appropriateness and necessity of parameters for HFNC use in bronchiolitis. These recommendations allow for standardization of practice that may optimize outcomes and curb indiscriminate use of this respiratory support modality.

[1]*Department of Pediatrics, Johns Hopkins University School of Medicine, Baltimore, Maryland*
[2]*Division of Hospital Medicine, Johns Hopkins Children's Center, Baltimore, Maryland*
[3]*Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati, Ohio*
[4]*Division of Hospital Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio*
[5]*Section of Pediatric Hospital Medicine, Division of General Pediatrics, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania*
[6]*Division of Emergency Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio*
[7]*Department of Pediatrics, Perelman School of Medicine, University of Pennsylvania, Philadelphia, Pennsylvania*

Address correspondence to: Clea D. Harris, MD, Division of Pediatric Hospital Medicine, Johns Hopkins Children's Center, 1800 Orleans St, Baltimore, MD 21287. charr163@jh.edu

Dr Harris conceptualized and designed the study, designed the data collection instruments, extracted and synthesized evidence from the literature, recruited and selected expert panel members, drafted the initial manuscript, and critically reviewed and revised the manuscript. Drs Treasure and Schondelmeyer conceptualized and designed the study, designed the data collection instruments, extracted evidence from the literature, recruited and selected expert panel members, and critically reviewed and revised the manuscript. Ms Albanowski conceptualized and designed the study, designed the data collection instruments, recruited expert panel members, carried out data analyses, and critically reviewed and revised the manuscript. Drs Lipshaw, Bonafide, Schroeder, Noelck, Byrd, and Stalets conceptualized and designed the study and critically reviewed and revised the manuscript. Drs Menachof and Cane critically reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

CONFLICT OF INTEREST DISCLOSURES: The other authors have no conflicts of interest to disclose.

INTRODUCTION

High-flow nasal cannula (HFNC) is increasingly used in the inpatient management of bronchiolitis, such that more than half of children admitted to US hospitals with bronchiolitis receive this therapy.[1] Among this majority of hospitalized patients, only a fraction are critically ill.[2,3] Given the relatively low, stable rate of severe disease in healthy children with bronchiolitis, the trend toward increased HFNC use suggests it is being used in cases for which it may not confer any clinical benefit. HFNC has not been demonstrated to reduce illness severity or decrease length of stay (LOS) in patients admitted with bronchiolitis.[4–10] In fact, the use of HFNC in bronchiolitis has been correlated with increased intensive care unit (ICU) use without concurrent escalation in respiratory support.[5,8,9,11–18] The questionable benefit of widespread HFNC use for bronchiolitis in non–critically ill children is pertinent to consider in light of its substantially higher costs when compared with low-flow nasal cannula (LFNC).[19–21] Multiple studies have demonstrated that HFNC may be optimally trialed as a rescue therapy in the approximately 30% of patients whose symptoms are refractory to LFNC; in half of these patients, this trial successfully averts further escalation of respiratory support, and thus, HFNC is ultimately continued.[12,20,22–24] Despite this guidance and aforementioned limitations of HFNC, it is nevertheless used in most bronchiolitis admissions in the United States.[1–3,15] This high proportion of HFNC use is particularly striking when considering that bronchiolitis is the most common reason for non-birth-related hospital admissions of US infants.[25]

Current national bronchiolitis guidelines do not address the appropriate use of HFNC for hospitalized children.[26] Studies examining HFNC use outside the ICU setting, including multiple randomized clinical trials (RCTs), are heterogeneous across multiple domains, including age cutoffs for the diagnosis of bronchiolitis, criteria for HFNC initiation, flow rates used, and definitions of HFNC failure. This inconsistency aligns with practice variation nationally, suggesting variable knowledge or interpretation of this literature. Standardizing clinical practice and recognizing areas of low-value care can reduce unnecessary use of health care resources and improve patient outcomes.[27–30] In scenarios where evidence is present but not sufficiently detailed to change clinical practice, a modified Delphi approach that uses existing evidence and expert judgment can help move toward discrete, evidence-driven recommendations for practice. We combined the best available evidence with the insights of a multidisciplinary national expert panel to develop recommendations for HFNC use for bronchiolitis outside of the ICU.

METHODS

Study Design

We used the Research and Development (RAND)/University of California, Los Angeles Appropriateness Method (RAM).[31] The RAM was designed for and has been used extensively in medicine to identify and evaluate evidence-driven clinical practice recommendations by means of existing evidence and expert judgment.[32–38] It was intended for scenarios in which scientific literature is limited in quantity and/or quality, thus resulting in unwarranted practice variation. It combines existing evidence with expert judgment through a structured rating process with strict definitions of appropriateness and necessity.

This study was reviewed by the hospital's institutional review board and determined to be exempt. Panelists were offered $400 honoraria in recognition of the time required to review evidence, complete rating sessions, and participate in a panel meeting.

Team Formation and Expert Panel Selection

We formed a multidisciplinary study team composed of individuals with research and/or clinical expertise in the care of hospitalized children. An initial meeting was held to discuss and refine the focus for the study and subsequent literature search. We also sought input from a family advisory committee at the primary institution about the relevance of the study focus, who recommended our team seek input from a broad set of parents of hospitalized children before implementing the outcomes from the RAM process. Our multidisciplinary research team then approached leaders of relevant national professional nursing, respiratory therapy, physician, and patient safety organizations to nominate expert panelists. After reviewing curricula vitae of nominees for applicable expertise and evidence of any bias that might affect their suitability as panelists, we interviewed nominees to identify potential conflicts of interest. To maintain a manageable panel size[31] and to ensure representation among roles and disciplines (research, administrative, and clinical background) and practice setting (community vs university-affiliated), we approached a subset of nominees to serve as panelists. From the original nominees, we identified 15 willing panel members, all of whom participated in the full process (Supplemental Table 1). Panelists represented a range of professions (nursing, respiratory therapy, and medicine), with diverse clinical expertise (intensive care, emergency medicine, and hospital-based care) in a variety of hospital settings (community settings and large children's hospitals) and roles (research, administrative, and clinical).

Literature Search and Creation of Recommendations

The research team consulted a medical librarian, who constructed a comprehensive search strategy. Search terms included a main subject matter of bronchiolitis combined with terms pertaining to HFNC. Databases searched included MEDLINE (Ovid), Cumulative Index to Nursing and Allied Health Literature, Cochrane, and Edward L. Pratt Research Library (University of Cincinnati Libraries). English-language articles published in academic and/or peer-reviewed journals were included. They were grouped and filtered by the research librarian and sent to the study team.

Using this strategy, 306 unique titles were identified. Three study team members (CDH, JDT, and ACS) each screened a subset of these titles for relevance and reviewed abstracts of screened articles for pertinence and evidence quality. Additional articles were identified by reviewing article reference lists and the authors' personal reference libraries. Ultimately, 509 titles were screened for relevance, 257 studies were assessed for eligibility, and 203 studies were included

(Figure 1). These 3 study team members reviewed the 203 selected full-text articles and extracted information about study design, population, and results using a structured review form. The team assigned a level of evidence for each study and an aggregate literature quality rating based on the Oxford Centre for Evidence-Based Medicine Levels of Evidence.[39]

Literature summaries were generated and organized by phase of care: initiation of HFNC, reassessment of patients supported by HFNC, escalation of care, and de-escalation of HFNC. A list of relevant terms and definitions was created (Supplemental Figure 1A). Specific attention was given to characterizing the dynamic and subjective threshold of respiratory decompensation. In the absence of validated scoring systems for respiratory distress in bronchiolitis, panelists were instructed to use an operational definition of "impending respiratory failure" to denote the point at which a child may imminently require positive-pressure ventilation or intubation to maintain airway patency. Similarly, given the variation in defining a precise threshold for "hypoxemia," panelists were directed to consider hypoxemia to be an actionably decreased oxygen saturation (SpO_2), as defined by local and institutional practice (typically, $SpO_2 < 87\%$-90%).

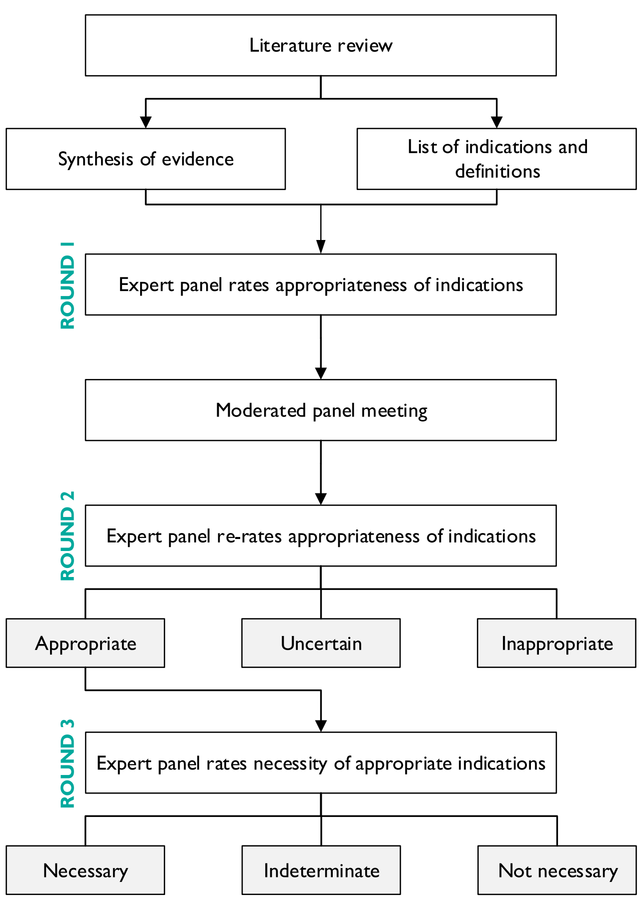

FIGURE 1. Steps in the Research and Development (RAND)/University of California, Los Angeles Appropriateness Method.

Based on the literature, we drafted proposed indications for the use of HFNC, associated settings, and monitoring parameters. We created a recommendation within each indication for its applicability to children aged 1-12 months and/or greater than 12-24 months to reflect the age cutoffs for bronchiolitis most commonly described in the literature.[25] Supplemental Figure 1B-C includes the literature search results, list of terms, and full list of recommendations.

All study team members reviewed recommendations and evidence summary in depth for clarity and completeness. We specifically sought detailed input on the wording of evidence summaries and recommendations from 2 study team members with extensive experience caring for infants with bronchiolitis in rural and community hospital settings.

Rating the Recommendations

Before the rating sessions, panelists were briefed on the RAM, including its instruction to consider "an average patient presenting to an average physician . . . in an average hospital."[31] They were provided the opportunity to clarify language in definitions, evidence summaries, or recommendations and to suggest additional recommendations and/or relevant literature.

In the first round, we provided evidence summaries reviewing key findings and studies that informed recommendations. Using Research Electronic Data Capture (REDCap),[40,41] panelists independently rated each recommendation on a standard 9-point Likert scale of appropriateness. We defined appropriateness as the degree to which the benefits of HFNC outweighed the risks.[31] We assessed scores for disagreement on the basis of the median and range of ratings.[31]

Recommendations for which there was agreement were considered appropriate if the median panelist rating was between 7 and 9, of uncertain appropriateness if the median was between 4 and 6, or inappropriate if the median was between 1 and 3.

After the first round, panelists participated in a moderated video conference, a previously published modification on the RAM.[32,33,35,38] The moderator, who had considerable prior experience with this method, guided the panelists' discussion of round 1 ratings for which there was uncertain appropriateness or disagreement, working to elucidate whether disagreement was related to lack of clarity on the recommendation wording or on differences in interpretation of the literature. Following the session, the research team made nominal revisions to improve clarity of the recommendations and panelists independently completed a second round of individual ratings. The ratings were again assessed for agreement and appropriateness.

The third and final round of ratings was conducted to assess the necessity of recommendations that the panelists had already determined to be appropriate. In RAM terms, necessary recommendations are those for which it would be improper care not to follow the practice and thus have a higher threshold to meet than appropriateness.[31] Panelists were provided updated rating forms for only the recommendations deemed appropriate after the second round. Recommendations were rated on 9-point Likert scales, from completely unnecessary to completely necessary. Finally, necessity scores were assessed for disagreement, as described above, and recommendations were classified as necessary (median score of 7–9), of uncertain necessity (median score of 4–6), and appropriate but unnecessary (median score of 1–3 or presence of disagreement).[31]

As per best practices for RAM processes, after the conclusion of ratings, panelists completed an anonymous process evaluation adapted from a previously described questionnaire assessing the time used and experience participating in the rating process (Supplemental Figure 2).[31,42]

RESULTS

Of the 60 original recommendations, panelists reached agreement on the appropriateness of 52 and on the necessity of 46. All necessary recommendations were first rated as appropriate. There was no discordance between recommendations for patients aged 1-12 months vs greater than 12-24 months. A visual summary of panel recommendations can be found in Figure 2, and the full list of recommendations, including final panelist ratings, can be found in Supplemental Figure 3.

Initiating HFNC

When to Initiate HFNC

Panelists rated it necessary to trial LFNC before HFNC for patients with hypoxemia and to initiate HFNC for respiratory distress and hypoxemia refractory to LFNC. In the absence of hypoxemia or impending respiratory failure, they rated it necessary to abstain from HFNC initiation.

It was considered appropriate, but of uncertain necessity, to avoid initiating HFNC based solely on a patient's respiratory score.

The panelists rated it necessary to avoid assessments of end-tidal carbon dioxide ($ETCO_2$), P_{CO2}, or pH before initiating HFNC. In the event

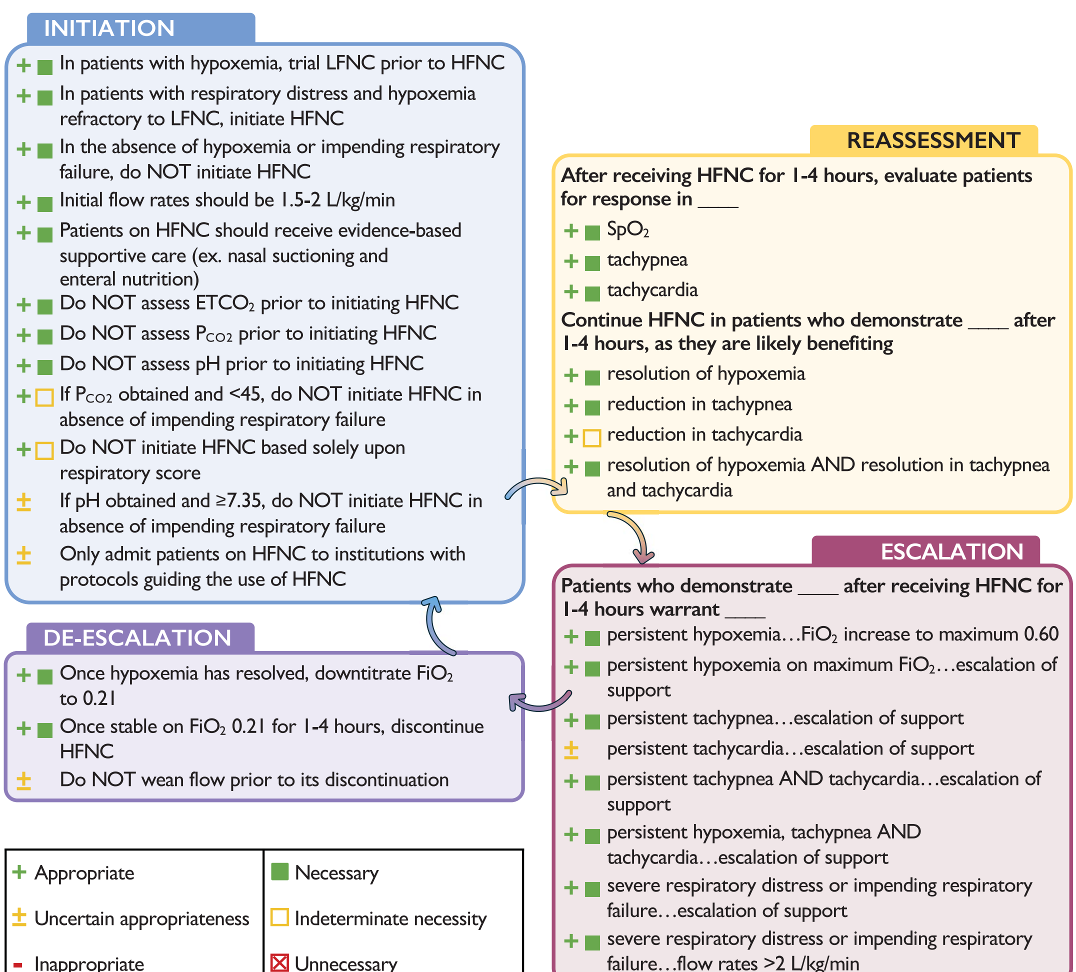

FIGURE 2. Panel findings.
Abbreviations: FiO_2, fraction of inspired oxygen; HFNC, high-flow nasal cannula; LFNC, low-flow nasal cannula; SpO_2, oxygen saturation.

these laboratory measures of respiratory insufficiency are obtained, however, the panelists provided recommendations regarding their impact on HFNC initiation. If P_{CO2} is less than 45 mm Hg in a patient without impending respiratory failure, it is appropriate but of uncertain necessity to defer HFNC initiation. If pH is 7.35 or greater in a patient without impending respiratory failure, there is uncertain appropriateness to defer HFNC initiation.

HFNC Initiation Parameters

Initial flow rates of 1.5-2 L/kg/min were rated as necessary. It was also rated necessary to provide patients receiving HFNC with evidence-based supportive care (ie, enteral nutrition). Panelists found uncertain appropriateness to restricting the admission of patients with HFNC to institutions with protocols guiding its use.

Reassessing Patients

Panelists rated it necessary to reassess patients receiving HFNC 1-4 hours after initiation for response in SpO_2, tachypnea, and tachycardia. They rated it necessary to continue HFNC in patients who demonstrate resolution of hypoxemia or reduction in tachypnea. Similarly, it is necessary to continue HFNC in patients with resolution of hypoxemia in conjunction with reduction in tachypnea and tachycardia. Panelists found it appropriate but of uncertain necessity to continue HFNC in patients who only demonstrate reduction in tachycardia in the absence of other vital sign changes.

Escalating Care

For patients who demonstrate persistent hypoxemia after 1-4 hours of HFNC, panelists rated up-titration of fraction of inspired oxygen (FiO_2) to a maximum of 0.6 as necessary. They also rated it necessary to escalate respiratory support for patients with persistent hypoxemia despite maximum FiO_2 and for patients who have received HFNC for 1-4 hours yet demonstrate persistent tachypnea; persistent tachypnea and tachycardia; or persistent hypoxemia, tachypnea, and tachycardia. Escalating support in patients solely with persistent tachycardia after receiving HFNC for 1-4 hours was of uncertain appropriateness.

The panel rated it necessary to escalate support in patients with severe respiratory distress or impending respiratory failure after receiving HFNC for 1-4 hours. In this subset of patients, they rated it necessary to escalate flow rates to >2 L/kg/min.

De-escalating HFNC

The panel rated it necessary to down-titrate FiO_2 to 0.21 once hypoxemia has resolved. When patients have been stable on FiO_2 0.21 for 1-4 hours, the panel rated it necessary to discontinue HFNC. They found uncertain appropriateness to avoid weaning flow before discontinuing HFNC.

Process Evaluation

Panelists reported spending an average of 7.5 hours completing evidence review and ratings. Eighty-seven percent of panelists (13/15) positively described their experience with this process. Open-ended responses included positive experiences of the moderated panel discussion. Full details are in Supplemental Figure 2.

DISCUSSION

Using the RAM, a national expert panel reached agreement on appropriate and necessary recommendations for the use of HFNC in bronchiolitis. Following these recommendations ultimately may limit HFNC such that it is only used in patients for whom it provides clinical benefit. The panel agreed on initiating HFNC only for hypoxemia or impending respiratory failure, and at flow rates of at least 1.5 L/kg/min. They recommended discontinuation of HFNC once a patient is stable with FiO_2 of 0.21 for 1-4 hours. The panel's recommendations, which combine available evidence and expert judgment, are intended to guide clinicians balancing the harms of HFNC with the risks of respiratory failure. In publishing these recommendations, we aim to facilitate the development of rigorous, evidence-driven local guidelines for the management of bronchiolitis.

The use of HFNC in the management of bronchiolitis does not have a robust body of literature supporting its necessity or benefit, particularly when compared with the neonatal ICU, where HFNC has long been considered evidence-based in the post-extubation period and for treating apnea of prematurity.[43–46] Despite this limitation, HFNC was rapidly adopted for use in non–critically ill patients with bronchiolitis. No expert recommendations have yet been published for the rational use of HFNC in bronchiolitis outside of the ICU.[37] Our study aims to address this gap.

This framing is particularly relevant as ward-based HFNC use in bronchiolitis management has surged, leading local and national groups to pursue strategies to curtail its use and reduce its correlated increased LOS.[1,7–9,14,15,17,27,28,30,47–55] This task has been accomplished using a variety of methods, including pausing before using HFNC, initiating it only for hypoxemia or impending respiratory failure, using weight-based flow rates, and rapidly weaning HFNC once vital signs have normalized.[1,27,28,30,47,50,56] Integrating these approaches with the panel's recommendations establishes a foundation for the creation of consistent and specific guidelines, thus facilitating the delivery of high-value care for infants with bronchiolitis nationwide.

Limitations

The preparatory literature search highlighted challenges in recent and ongoing studies. As previously mentioned, the current body of evidence varies widely in definitions of key terms, including "bronchiolitis," "hypoxemia," and "respiratory distress." Additionally, the absence of a validated scoring tool for respiratory distress in bronchiolitis[57,58] limited the ability to interpret the literature and to craft recommendations based upon a standardized clinical assessment of the patient's work of breathing.

As is common in pediatric hospital medicine, these challenges were further compounded by limitations in evidence quality, which included mostly cohort studies and quality improvement projects, with a relative paucity of RCTs and meta-analyses. The evidence was occasionally difficult to assimilate, given inconsistencies in the parameters used. Studies of HFNC use variably included patients with bronchiolitis who were aged less than 6 months vs less than 12 months vs less than 24 months. Additionally, there was variation in the HFNC flow rates used; they were inconsistently weight-based, spanning wide ranges, and were either set at fixed rates or titrated. Multiple experimental studies allowed crossover from LFNC to HFNC, limiting the ability to appreciate the true scope of HFNC failure compared with LFNC.[20,24] In all, these dynamics create situations for different interpretations of the same studies.

Results of the RAM process can be influenced by the panel's composition.[31] We anticipated and mitigated this risk by recruiting nominees from a broad array of professional organizations, with a range of clinical practice expertise and other backgrounds to ensure a diverse representation of opinions. While the RAM uses an expert panel to interpret and adjudicate in situations where evidence is sparse, as with all studies reliant on current evidence, these findings may evolve as more studies are published.

Future Directions

These recommendations are meant to be applied to most children hospitalized with bronchiolitis on a general pediatrics service and, when implemented, are expected to result in safe reductions in use of HFNC. The broad scope of their application is appropriate based on the current evidence, but we acknowledge patient age, lung maturity, genetics, viruses causing bronchiolitis, severity of illness, family history, comorbid conditions, and illness stage (from symptom onset, to peak, to recovery) all interact to affect the outcome of bronchiolitis. More clinical effectiveness research in the coming years will further delineate the benefits and drawbacks of HFNC use in specific populations. Such studies should include community hospital settings, rural communities, and historically underrepresented groups to ensure a diverse population is represented.[59] Additionally, future work may build upon the growing body of literature surrounding evidence-based supportive care for children receiving HFNC, such as optimization of enteral feeding regimens as well as nasal suctioning.

Further work is needed to improve the care of non–critically ill patients receiving HFNC for bronchiolitis, specifically surrounding multidisciplinary coordination and education about its use.[47,60,61] Implementing these recommendations in multisite hybrid implementation-effectiveness trials may allow for better delineation of best practices. Such studies could inform implementation best practices and quantify impacts of the recommendations on care quality and value, as well as clinician, patient, and family experience.

CONCLUSIONS

Using the RAM, an expert panel reached agreement on appropriate and necessary recommendations for non-ICU use of HFNC in bronchiolitis. The panel consistently endorsed HFNC should be used only in the setting of abnormal vital signs refractory to lower support modalities, should be administered at a rate of 1.5-2 L/kg/min, and should be discontinued once the patient is no longer hypoxemic. Future work should focus on understanding barriers to appropriate use of HFNC and developing best practices for implementing these recommendations into clinical practice, in tandem with rigorous measurement of patient outcomes.

Acknowledgments

We thank our expert panelists for their contributions to this work: Joyce Baker, MBA, RRT, RRT-NPS, AE-C, FAARC; Mandy De Vries, MSc, RRT, RRT-NPS; Eliza Holland, MD; Asumthia Jeyapalan, DO, MHA; Jie Li, PhD, RRT, RRT-NPS, RRT-ACCS, FAARC; Peggy MacKay, RN; Melissa McLoone, RN, BSN; Andrew Miller, MSc, RRT-ACCS, RRT-NPS, FAARC, FCCM; Tiffany Mullen, MSN, RN, ACCNS-P, CCR; Joshua Nagler, MD, MHPEd; Kriston Reneau, RN; Daniel Slubowski, MD; Sheri Wagner, MD; Andy Wen, MD; and Robert Willer, DO. We thank Maria Britto, MD, MPH, for serving as expert panel moderator. We acknowledge the contributions of Ms Karen Vonderhaar, MS, BSN, and Ms Danette Lopp, MA, MPH, Evidence-Based Decision Making Consultants, for their assistance with the literature search and methodology.

ABBREVIATIONS

$ETCO_2$: end-tidal carbon dioxide
FiO_2: fraction of inspired oxygen
HFNC: high-flow nasal cannula
ICU: intensive care unit
LOS: length of stay
LFNC: low-flow nasal cannula
RAM: RAND/University of California, Los Angeles Appropriateness Method
RAND: Research and Development
RCT: randomized clinical trial
REDCap: Research Electronic Data Captur
SpO_2: oxygen saturation

[8]*Division of Hospital Medicine, Department of Pediatrics, Stanford University School of Medicine, Palo Alto, California*
[9]*Department of Pediatrics, Oregon Health and Science University School of Medicine, Portland, Oregon*
[10]*Department of Pediatrics, Emory University School of Medicine, Atlanta, Georgia*
[11]*Division of Critical Care Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio*
[12]*Pediatric Center, Johns Hopkins Bayview Medical Center, Baltimore, Maryland*
[13]*Chinle Comprehensive Health Care Facility, Navajo Area Indian Health Service, Chinle, Arizona*
[14]*James M. Anderson Center for Health Systems Excellence, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio*

FUNDING: This project was funded by the James M. Anderson Center for Health Systems Excellence at Cincinnati Children's Hospital. The concept was supported by the Pediatric Research in Inpatient Settings (PRIS) Network. The James M. Anderson Center for Health Systems Excellence at Cincinnati Children's Hospital had no role in the design and conduct of the study.

Accepted for Publication Date: June 27, 2025

https://doi.org/10.1542/hpeds.2025-008398

REFERENCES

1. Byrd C, Noelck M, Kerns E, et al. Multicenter study of high-flow nasal cannula initiation and duration of use in bronchiolitis. *Hosp Pediatr.* 2023;13(4):e69–e75. PubMed doi: 10.1542/hpeds.2022-006965
2. Panciatici M, Fabre C, Tardieu S, et al. Use of high-flow nasal cannula in infants with viral bronchiolitis outside pediatric intensive care units. *Eur J Pediatr.* 2019;178(8):1479–1484. PubMed doi: 10.1007/s00431-019-03434-4
3. Turnham H, Agbeko RS, Furness J, Pappachan J, Sutcliffe AG, Ramnarayan P. Non-invasive respiratory support for infants with bronchiolitis: a national survey of practice. *BMC Pediatr.* 2017;17(1):20. PubMed doi: 10.1186/s12887-017-0785-0
4. Choi J, Park E, Park H, et al. Effect of high-flow nasal cannula on mechanical ventilator duration in bronchiolitis patients. *Respir Med.* 2022;201:106946. PubMed doi: 10.1016/j.rmed.2022.106946
5. Coon ER, Stoddard G, Brady PW. Intensive care unit utilization after adoption of a ward-based high-flow nasal cannula protocol. *J Hosp Med.* 2020;15(6):325–330. PubMed doi: 10.12788/jhm.3417
6. Kooiman L, Blankespoor F, Hofman R, et al. High-flow oxygen therapy in moderate to severe bronchiolitis: a randomised controlled trial. *Arch Dis Child.* 2023;108(6):455–460. PubMed doi: 10.1136/archdischild-2022-324697
7. Lipshaw MJ, Vukovic AA, Dean P, et al. High-flow nasal cannula in bronchiolitis at a pediatric emergency department: trends and outcomes. *Hosp Pediatr.* 2021;11(2):119–125. PubMed doi: 10.1542/hpeds.2020-002774
8. Mace AO, Gibbons J, Schultz A, Knight G, Martin AC. Humidified high-flow nasal cannula oxygen for bronchiolitis: should we go with the flow? *Arch Dis Child.* 2018;103(3):303. PubMed doi: 10.1136/archdischild-2017-313950
9. Riese J, Porter T, Fierce J, Riese A, Richardson T, Alverson BK. Clinical outcomes of bronchiolitis after implementation of a general ward high flow nasal cannula guideline. *Hosp Pediatr.* 2017;7(4):197–203. PubMed doi: 10.1542/hpeds.2016-0195
10. Tang G, Lin J, Zhang Y, Shi Q. The effects and safety of continuous positive airway pressure in children with bronchiolitis: a systematic review and meta-analysis. *J Trop Pediatr.* 2021;67(2):fmaa128. PubMed doi: 10.1093/tropej/fmaa128
11. Alverson B, Ralston S. ICU use in bronchiolitis: why has it doubled? *Pediatrics.* 2021;147(6):e2020046276. PubMed doi: 10.1542/peds.2020-046276
12. Franklin D, Babl FE, George S, et al. 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;329(3):224–234. PubMed doi: 10.1001/jama.2022.21805
13. Lin J, Zhang Y, Xiong L, Liu S, Gong C, Dai J. High-flow nasal cannula therapy for children with bronchiolitis: a systematic review and meta-analysis. *Arch Dis Child.* 2019;104(6):564–576. PubMed doi: 10.1136/archdischild-2018-315846
14. Schlapbach LJ, Straney L, Gelbart B, et al; Australian & New Zealand Intensive Care Society (ANZICS) Centre for Outcomes & Resource Evaluation (CORE) and the Australian & New Zealand Intensive Care Society (ANZICS) Paediatric Study Group. Burden of disease and change in practice in critically ill infants with bronchiolitis. *Eur Respir J.* 2017;49(6):1601648. PubMed doi: 10.1183/13993003.01648-2016
15. O'Brien S, Haskell L, Schembri R, et al; Paediatric Research in Emergency Departments International Collaborative (PREDICT) network, Australasia. Prevalence of high flow nasal cannula therapy use for management of infants with bronchiolitis in Australia and New Zealand. *J Paediatr Child Health.* 2022;58(12):2230–2235. PubMed doi: 10.1111/jpc.16199
16. Pelletier JH, Au AK, Fuhrman D, Clark RSB, Horvat C. Trends in bronchiolitis ICU admissions and ventilation practices: 2010-2019. *Pediatrics.* 2021;147(6):e2020039115. PubMed doi: 10.1542/peds.2020-039115
17. Pham H, Thompson J, Wurzel D, Duke T. Ten years of severe respiratory syncytial virus infections in a tertiary paediatric intensive care unit. *J Paediatr Child Health.* 2020;56(1):61–67. PubMed doi: 10.1111/jpc.14491
18. Piper L, Stalets EL, Statile AM. Clinical progress note: high flow nasal cannula therapy for bronchiolitis outside the ICU in infants. *J Hosp Med.* 2020;15(1):49–51. PubMed doi: 10.12788/jhm.3328
19. Gc VS, Franklin D, Whitty JA, et al. First-line oxygen therapy with high-flow in bronchiolitis is not cost saving for the health service. *Arch Dis Child.* 2020;105(10):975–980. PubMed doi: 10.1136/archdischild-2019-318427

20. Kepreotes E, Whitehead B, Attia J, 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. *Lancet.* 2017;389(10072):930–939. PubMed doi: 10.1016/S0140-6736(17)30061-2

21. Modesto i Alapont V, Garcia Cuscó M, Medina A. High-flow oxygen therapy in infants with bronchiolitis. *N Engl J Med.* 2018;378(25):2444–2447. PubMed doi: 10.1056/NEJMc1805312

22. Daverio M, Da Dalt L, Panozzo M, Frigo AC, Bressan S. A two-tiered high-flow nasal cannula approach to bronchiolitis was associated with low admission rate to intensive care and no adverse outcomes. *Acta Paediatr.* 2019;108(11):2056–2062. PubMed doi: 10.1111/apa.14869

23. Durand P, Guiddir T, Kyheng C, et al; Bronchopti study group. A randomised trial of high-flow nasal cannula in infants with moderate bronchiolitis. *Eur Respir J.* 2020;56(1):1901926. PubMed doi: 10.1183/13993003.01926-2019

24. Franklin D, Babl FE, Schlapbach LJ, et al. A randomized trial of high-flow oxygen therapy in infants with bronchiolitis. *N Engl J Med.* 2018;378(12):1121–1131. PubMed doi: 10.1056/NEJMoa1714855

25. Dalziel SR, Haskell L, O'Brien S, et al. Bronchiolitis. *Lancet.* 2022;400(10349):392–406. PubMed doi: 10.1016/S0140-6736(22)01016-9

26. Ralston SL, Lieberthal AS, Meissner HC, et al; American Academy of Pediatrics. Clinical practice guideline: the diagnosis, management, and prevention of bronchiolitis. *Pediatrics.* 2014;134(5):e1474–e1502. PubMed doi: 10.1542/peds.2014-2742

27. Byrd C, Noelck M, Kerns E, et al. Multicenter quality collaborative to reduce overuse of high-flow nasal cannula in bronchiolitis. *Pediatrics.* 2024;153(5):e2023063509. PubMed doi: 10.1542/peds.2023-063509

28. Willer RJ, Johnson MD, Cipriano FA, et al. Implementation of a weight-based high-flow nasal cannula protocol for children with bronchiolitis. *Hosp Pediatr.* 2021;11(8):891–895. PubMed doi: 10.1542/hpeds.2021-005814

29. Treasure JD, Hubbell B, Statile AM. Enough is enough: quality improvement to deimplement high-flow nasal cannula in bronchiolitis. *Hosp Pediatr.* 2021;11(4):e54–e56. PubMed doi: 10.1542/hpeds.2021-005849

30. Willer RJ, Brady PW, Tyler AN, Treasure JD, Coon ER. Transition to weight-based high-flow nasal cannula use outside of the ICU for bronchiolitis. *JAMA Netw Open.* 2024;7(3):e242722. PubMed doi: 10.1001/jamanetworkopen.2024.2722

31. Fitch K, Bernstein SJ, Aguilar MD, et al. *RAND/UCLA Appropriateness Method User's Manual.* RAND; 2000.

32. Wood JN, Fakeye O, Feudtner C, Mondestin V, Localio R, Rubin DM. Development of guidelines for skeletal survey in young children with fractures. *Pediatrics.* 2014;134(1):45–53. PubMed doi: 10.1542/peds.2013-3242

33. Wood JN, Fakeye O, Mondestin V, Rubin DM, Localio R, Feudtner C. Development of hospital-based guidelines for skeletal survey in young children with bruises. *Pediatrics.* 2015;135(2):e312–e320. PubMed doi: 10.1542/peds.2014-2169

34. Shekelle PG, Chassin MR, Park RE. Assessing the predictive validity of the RAND/UCLA appropriateness method criteria for performing carotid endarterectomy. *Int J Technol Assess Health Care.* 1998;14(4):707–727. PubMed doi: 10.1017/S0266462300012022

35. Paine CW, Scribano PV, Localio R, Wood JN. Development of guidelines for skeletal survey in young children with intracranial hemorrhage. *Pediatrics.* 2016;137(4):e20153024. PubMed doi: 10.1542/peds.2015-3024

36. Chopra V, Flanders SA, Saint S, et al; Michigan Appropriateness Guide for Intravenouse Catheters (MAGIC) Panel. The Michigan Appropriateness Guide for Intravenous Catheters (MAGIC): results from a multispecialty panel using the RAND/UCLA Appropriateness Method. *Ann Intern Med.* 2015;163(6 suppl):S1–S40. PubMed doi: 10.7326/M15-0744

37. Milési C, Baudin F, Durand P, et al; French Speaking Group for Pediatric Intensive and Emergency Care. Clinical practice guidelines: management of severe bronchiolitis in infants under 12 months old admitted to a pediatric critical care unit. *Intensive Care Med.* 2023;49(1):5–25. PubMed doi: 10.1007/s00134-022-06918-4

38. Schondelmeyer AC, Dewan ML, Brady PW, et al. Cardiorespiratory and pulse oximetry monitoring in hospitalized children: a Delphi process. *Pediatrics.* 2020;146(2):e20193336. PubMed doi: 10.1542/peds.2019-3336

39. OECBM Levels of Evidence Working Group. The Oxford Levels of Evidence 2. Oxford Centre for Evidence-Based Medicine. Accessed May 16, 2024. https://www.cebm.ox.ac.uk/resources/levels-of-evidence/ocebm-levels-of-evidence

40. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: building an international community of software platform partners. *J Biomed Inform.* 2019;95:103208. PubMed doi: 10.1016/j.jbi.2019.103208

41. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research Electronic Data Capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009;42(2):377–381. PubMed doi: 10.1016/j.jbi.2008.08.010

42. Sparks JB, Klamerus ML, Caverly TJ, et al. Planning and reporting effective web-based RAND/UCLA Appropriateness Method panels:

literature review and preliminary recommendations. *J Med Internet Res.* 2022;24(8):e33898. PubMed doi: 10.2196/33898

43. Abboud PA, Roth PJ, Skiles CL, Stolfi A, Rowin ME. Predictors of failure in infants with viral bronchiolitis treated with high-flow, high-humidity nasal cannula therapy*. *Pediatr Crit Care Med.* 2012;13(6):e343–e349. PubMed doi: 10.1097/PCC.0b013e31825b546f

44. Bresesti I, Lista G. Respiratory support of neonate affected by bronchiolitis in neonatal intensive care unit. *Am J Perinatol.* 2020;37(S 02):S10–S13. PubMed doi: 10.1055/s-0040-1713604

45. Hough JL, Pham TMT, Schibler A. Physiologic effect of high-flow nasal cannula in infants with bronchiolitis. *Pediatr Crit Care Med.* 2014;15(5):e214–e219. PubMed doi: 10.1097/PCC.0000000000000112

46. Lee JH, Rehder KJ, Williford L, Cheifetz IM, Turner DA. Use of high flow nasal cannula in critically ill infants, children, and adults: a critical review of the literature. *Intensive Care Med.* 2013;39(2):247–257. PubMed doi: 10.1007/s00134-012-2743-5

47. Charvat C, Jain S, Orenstein EW, Miller L, Edmond M, Sanders R. Quality initiative to reduce high-flow nasal cannula duration and length of stay in bronchiolitis. *Hosp Pediatr.* 2021;11(4):309–318. PubMed doi: 10.1542/hpeds.2020-005306

48. Huang JX, Colwell B, Vadlaputi P, et al. Protocol-driven initiation and weaning of high-flow nasal cannula for patients with bronchiolitis: a quality improvement initiative. *Pediatr Crit Care Med.* 2023;24(2):112–122. PubMed doi: 10.1097/PCC.0000000000003136

49. Maue DK, Ealy A, Hobson MJ, et al. Improving outcomes for bronchiolitis patients after implementing a high-flow nasal cannula holiday and standardizing discharge criteria in a PICU. *Pediatr Crit Care Med.* 2023;24(3):233–242. PubMed doi: 10.1097/PCC.0000000000003183

50. Noelck M, Foster A, Kelly S, et al. SCRATCH Trial: an initiative to reduce excess use of high-flow nasal cannula. *Hosp Pediatr.* 2021;11(4):319–326. PubMed doi: 10.1542/hpeds.2020-003913

51. Robinson A, Winer JC, Bettin K. Decreasing inappropriate supplemental oxygen with high-flow nasal cannula for bronchiolitis. *Hosp Pediatr.* 2023;13(4):e87–e91. PubMed doi: 10.1542/hpeds.2022-006914

52. Siraj S, Compton B, Russell B, Ralston S. Reducing high-flow nasal cannula overutilization in viral bronchiolitis. *Pediatr Qual Saf.* 2021;6(4):e420. PubMed doi: 10.1097/pq9.0000000000000420

53. de Benedictis FM. The effectiveness of high-flow oxygen therapy and the fascinating song of the sirens. *JAMA Pediatr.* 2019;173(2):125–126. PubMed doi: 10.1001/jamapediatrics.2018.3831

54. Goh CT, Kirby LJ, Schell DN, Egan JR. Humidified high-flow nasal cannula oxygen in bronchiolitis reduces need for invasive ventilation but not intensive care admission. *J Paediatr Child Health.* 2017;53(9):897–902. PubMed doi: 10.1111/jpc.13564

55. Mecklin M, Heikkilä P, Korppi M. The change in management of bronchiolitis in the intensive care unit between 2000 and 2015. *Eur J Pediatr.* 2018;177(7):1131–1137. PubMed doi: 10.1007/s00431-018-3156-4

56. Treasure JD, Lipshaw MJ, Dean P, et al. Quality improvement to reduce high-flow nasal cannula overuse in children with bronchiolitis. *Pediatrics.* 2023;152(3):e2022058758. PubMed doi: 10.1542/peds.2022-058758

57. Granda E, Urbano M, Andres P, Corchete M, Cano A, Velasco R. Comparison of severity scales for acute bronchiolitis in real clinical practice. *Eur J Pediatr.* 2023;182(4):1619–1626. PubMed doi: 10.1007/s00431-023-04840-5

58. Rodriguez-Martinez CE, Sossa-Briceño MP, Nino G. Systematic review of instruments aimed at evaluating the severity of bronchiolitis. *Paediatr Respir Rev.* 2018;25:43–57. PubMed doi: 10.1016/j.prrv.2016.12.006

59. Atwell JE, Hartman RM, Parker D, et al. RSV among American Indian and Alaska Native children: 2019 to 2020. *Pediatrics.* 2023;152(2):e2022060435. PubMed doi: 10.1542/peds.2022-060435

60. Gupta N, Port C, Jo D, et al. Acceptability of deimplementing high-flow nasal cannula in pediatric bronchiolitis. *Hosp Pediatr.* 2022;12(10):899–906. PubMed doi: 10.1542/hpeds.2022-006578

61. Marlow JA, Kalburgi S, Gupta V, et al; Pediatric Research in Inpatient Settings Network. Perspectives of health care personnel on the benefits of bronchiolitis interventions. *Pediatrics.* 2023;151(6):e2022059939. PubMed doi: 10.1542/peds.2022-059939