

Reducing High-flow Nasal Cannula Overutilization in Viral Bronchiolitis

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Abstract

Introduction: Heated high-flow nasal cannula (HHFNC) therapy for bronchiolitis has become increasingly prevalent without evidence that this therapy impacts patient outcomes. Lack of criteria for appropriate use may lead to overutilization, resulting in increased costs without patient benefit. Our primary aim was to decrease use of HHFNC in patients with bronchiolitis over one season. **Methods:** Patients with Bronchiolitis younger than 2 years of age admitted to the Hospital Medicine Service were included in this study. Using the model for improvement framework, we identified key drivers for HHFNC overuse and revised our bronchiolitis protocol to include low-flow nasal cannula trials before HHFNC initiation. We compared preintervention HHFNC utilization (December 2018–April 2019) with postintervention HFNC utilization (December 2019–March 2020). **Results:** One hundred ninety patients met inclusion criteria, 98 of them in the preintervention cohort and 92 in the postintervention cohort. Overall, the median age was 9 months and 65% of patients were male. Our HHFNC utilization rate decreased from 62% (61/98) to 43% (40/92) in the postintervention period. Our SPC analysis suggested special cause variation based on 7 points below the preintervention mean. **Conclusions:** This QI intervention implementing a specified low-flow nasal cannula trial before the initiation of HHFNC shows promise in reducing overall HHFNC use. Future studies should focus on clear initiation and discontinuation criteria for HHFNC use in bronchiolitis. (*Pediatr Qual Saf* 2021;6:e420; doi: 10.1097/pq9.000000000000420; Published online June 23, 2021.)

INTRODUCTION

Bronchiolitis is a leading cause of inpatient hospitalizations among children less than 2 years of age and is associated with estimated direct annual costs of over US \$700 million.¹ As such, many efforts have emerged to address the quality of care for bronchiolitis, stressing the importance of adhering to evidence-based guidelines for diagnosis and patient management.² Application of this framework has reduced usage of some nonevidence-based interventions



such as chest radiography, corticosteroids, viral testing, and bronchodilators.^{3–5}

Heated high-flow nasal cannula (HHFNC) oxygen has gained popularity in the care of patients with bronchiolitis but was not addressed in the 2014 guidelines.² Despite promising initial observational evidence on this intervention,^{6,7} the 2 randomized trials in hospitalized patients with moderate bronchiolitis provide clear evidence that early use of HHFNC does not impact outcomes.^{8,9} Kepreotes et al⁸ randomized 202 children with moderate bronchiolitis to either HHFNC or standard low-flow oxygen therapy upon admission. There were no differences in duration of oxygen therapy, overall length of stay (LOS), or pediatric intensive care unit (PICU) transfer rate. Franklin et al⁹ performed a similar randomized controlled trial including 1,472 patients, finding no differences in duration of oxygen therapy, length of hospital stay, or intubation rates. These findings echo more extensive observational studies in the United States and Canada, demonstrating no beneficial outcome effect in hospitals adopting wide use of HHFNC.^{10,11} Thus, the question of overutilization of this therapy has been raised.^{12–14}

Population-based data on appropriate rates of utilization of HHFNC in the general pediatric wards are lacking. Based on the existing randomized trial literature, we estimated that 70% of mild to moderate bronchiolitis could be successfully managed with standard low-flow oxygen.^{8,9} However, based on our clinical experience, we noted that at least half of our floor patients were

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managed with HHFNC. Thus, our specific aim of this quality improvement study was to decrease HHFNC use in patients less than two years of age with bronchiolitis by 50% over one season.

METHODS

Context

We conducted this quality improvement initiative in a 200-bed, free-standing children's hospital in Saint Petersburg, Florida, between December 2019 and March 2020. Approximately, 120 patients with acute viral bronchiolitis are admitted annually to our general pediatric ward. Importantly, we had an established institutional bronchiolitis pathway in place for 2 years before the project initiation. Our pathway includes a respiratory distress scoring system adapted from published work.¹⁵ The scoring tool served as a guide to categorize patients as mild, moderate, and severe bronchiolitis with interventions suggested by disease severity category (Figure 1, Supplemental Digital Content 1, which displays bronchiolitis severity score, <http://links.lww.com/PQ9/A266>). Patients admitted to the general pediatrics floor with bronchiolitis are all managed by the pediatric hospital medicine group and 1 of 2 different residency programs rotating in our hospital. Our pathway allows HHFNC use on the general pediatrics wards in previously healthy children with acute viral bronchiolitis at flow rates up to 12 L and FiO₂ up to 50%. However, criteria for initiation were nonspecific and there was no requirement that a patient be hypoxic before initiation of HHFNC.

Population

We included all patients age 1–24 months admitted to the general pediatric ward with acute viral bronchiolitis from December 2019 through March 2020. Every 2 weeks, charts of all patients receiving ICD-10 billing codes for acute viral bronchiolitis (J21.0, J21.1, J21.8, and J21.9) and/or acute respiratory failure (J96.00) were reviewed to identify patients initially admitted to the general pediatric floor to ensure they met clinical history and physical examination criteria consistent with bronchiolitis. Clinical criteria included, but were not limited to, items such as increased work of breathing, cough, feeding difficulties, congestion, tachypnea, and wheeze. Patients initially admitted to the PICU were excluded from this study. Using the same ICD-10 codes and inclusion/exclusion criteria, we obtained baseline data by performing a retrospective chart review of cases from December 2018 to April 2019 at our institution.

Intervention

We utilized the model for improvement framework for our quality improvement initiative.¹⁶ We performed a literature review and shared findings with key stakeholders in hospital medicine, emergency medicine, critical

care, and the residency program. We solicited their feedback on key drivers of HHFNC use and knowledge, attitudes, and beliefs about the therapy. We diagrammed key drivers of overuse of HHFNC (Fig. 1), and we chose to focus specifically on (1) lack of available guidance on initiation criteria for HHFNC use and (2) knowledge gaps about the current literature regarding the efficacy of HHFNC use.

We attempted to standardize formal HHFNC initiation criteria but struggled to reach consensus without published guidance on the topic. We ultimately proposed a single change to the existing emergency department and inpatient bronchiolitis algorithms for which we were able to achieve consensus. We added a trial of low-flow nasal cannula (LFNC) for at least 30 minutes with subsequent reassessment before initiation of HHFNC. This intervention was based on the randomized trial literature noting that 77% of patients placed on LFNC in the largest trial were successfully treated without further escalation of care.⁸ Our updated pathways are presented as Figure 2, Supplemental Digital Content 2, which displays ED bronchiolitis pathway. Intervention changes annotated in red, <http://links.lww.com/PQ9/A267> (ED) and Figure 3, Supplemental Digital Content 3, which displays inpatient bronchiolitis pathway. Intervention changes annotated in red, <http://links.lww.com/PQ9/A268> (inpatient) with the specific changes annotated. If there was no improvement in respiratory rate, tachycardia or hypoxia (oxygen saturation < 90%), patients were then placed on HHFNC. Improvement was determined by subjective consensus among team members.

We presented our rationale and subsequent modified algorithm to all stakeholders in multiple venues in November 2019. We also met with nursing and respiratory therapy leadership and attended their group meetings to discuss the changes. Resident physician education was performed at academic lectures and orientation to the ward service.

Measures

This study's primary outcome was the rate of HHFNC use in patients admitted to the general ward between December 2019 and March 2020, defined as the percentage of patients admitted to the general ward with viral bronchiolitis and who were placed on any HHFNC. Our process measure was protocol compliance, defined as the proportion of patients who received the recommended LFNC trial before HHFNC initiation. Our secondary outcome measure was hospital LOS.

To assess for the possibility of unintentional harm due to the protocol change, our balancing measure was rate of unplanned transfers to the PICU, defined as the proportion of bronchiolitis patients transferred from the ward to the ICU per unit of time. Given that unplanned PICU transfer was a relatively rare event, we also analyzed time between transfers as a potentially more sensitive balancing measure.

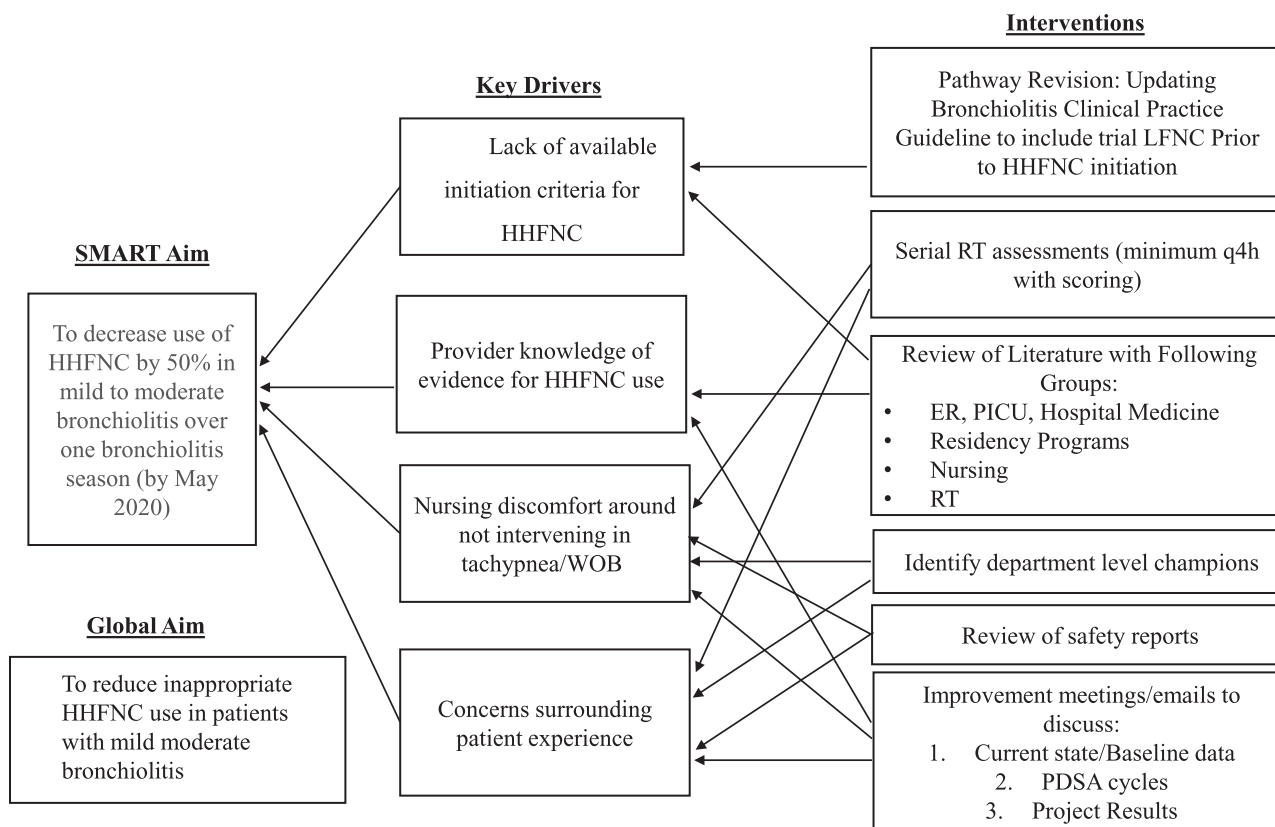


Fig. 1. Key driver diagram (KDD) for targeting HHFNC overuse in the general pediatric wards. ER, emergency room; PDSA, plan, do, study, act; RT, respiratory therapist; WOB, work of breathing.

Study of the Intervention

We provided feedback on the primary outcome and the process measure to stakeholders every two weeks using simple run charts. Team leaders continually discussed cases that did not adhere to the new algorithm to encourage feedback and familiarity with the change.

Analysis

We analyzed the data using statistical process control methods. Western Electric rules for establishing special cause were prespecified.¹⁷ Baseline values were calculated by using the 5 months of the preceding bronchiolitis season December 2018–April 2019. Postintervention data are reported December 2019–March 2020. We censored all data after mid-March due to the COVID-19 pandemic which terminated the bronchiolitis season early due to school closures and social distancing measures, resulting in a dramatic decline in hospital census. QI Macros (version 2020) was used to perform all SPC analyses.

Ethics

This QI project was deemed exempt by the Johns Hopkins All Children’s Hospital Institutional Review Board.

RESULTS

In this study, 182 patients admitted to the general pediatric ward with bronchiolitis were included. There were

a total of 98 patients in the baseline cohort and 84 in the postintervention cohort. Table 1 displays patient characteristics in each cohort. Overall, the median age was nine months and 65% of patients were male. Our HHFNC utilization rate decreased from 62% (61/98) to 48% (40/84) in the postintervention period. Our *P* chart suggested special cause variation based on 7 points below the baseline mean (Fig. 2). Among the patients placed on HHFNC, 39% (24/61) were initially trialed on standard LFNC before the initiation of HHFNC in the baseline period compared to 73% (29/40) in the postintervention period (Fig. 3). Our *P* chart suggested special cause based on 7 points below the baseline mean in the postintervention period.

Our balancing measure appeared unchanged, with 6 (6.1%) unplanned PICU transfers in the bronchiolitis population in the baseline period and 7 (7.6%) in the postintervention period. The time between

Table 1. Demographics for Study Population

Patient Characteristics	All Patients (n = 182)	Preintervention (n = 98)	Postintervention (n = 84)
Mean age, mo	9.0 + 7.0	9.9 + 7.9	8.0 + 5.6
Male	64.8% (118/182)	61.2% (60/98)	69% (58/84)
LOS, d	2.6 + 2.1	2.7 + 2.5	2.4 + 1.5
HHFNC	3.3 + 2.5	3.3 + 2.9	3.3 + 1.5
LFNC trial	3.4 + 2.1	3.4 + 2.6	3.4 + 1.7
LFNC only	1.8 + 1.1	1.8 + 0.67	1.6 + 0.84

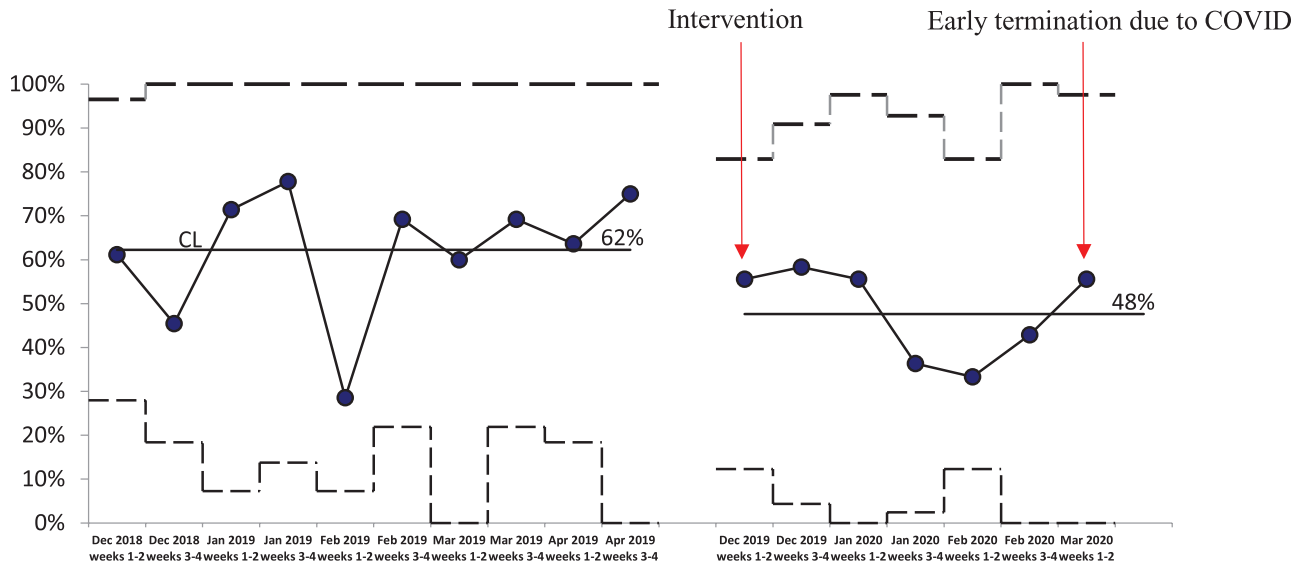


Fig. 2. Proportion of bronchiolitis patients receiving high-flow nasal cannula over total number of bronchiolitis patients admitted to the hospital medicine service (p Chart). The graph on the left represents the immediate preintervention seasonal data. The graph on the right represents data during the intervention season.

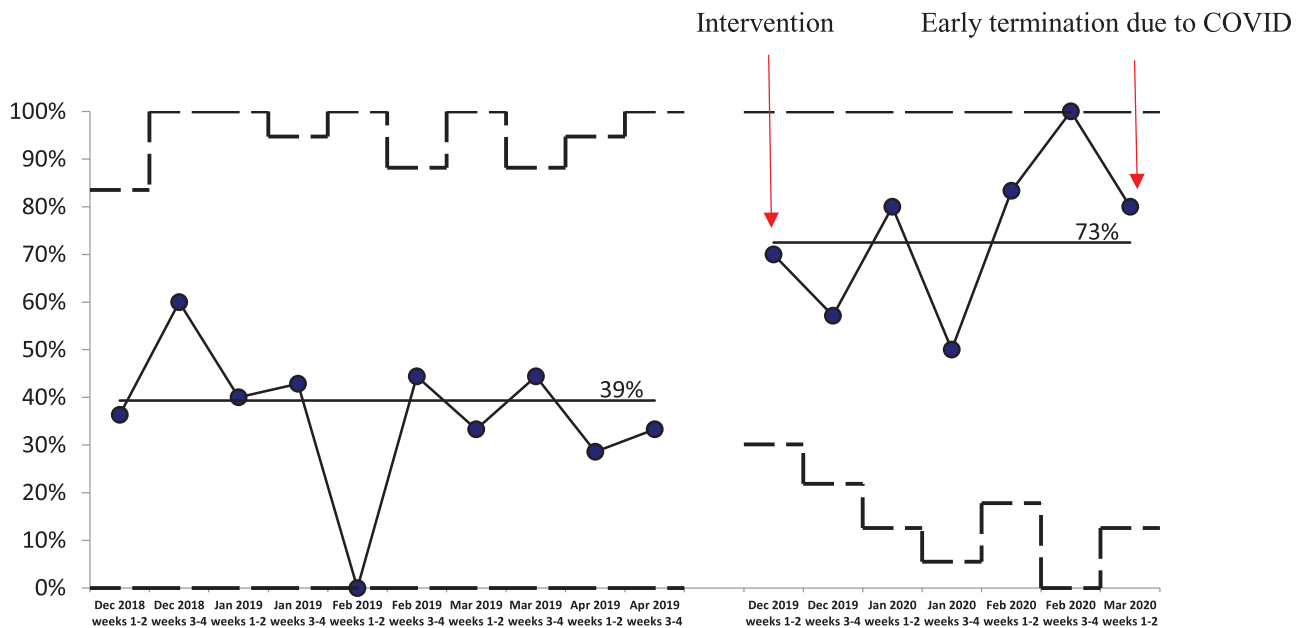


Fig. 3. Proportion of bronchiolitis patients receiving a trial of low-flow oxygen before high-flow nasal cannula initiation (p Chart). The graph on the left represents the immediate preintervention seasonal data. The graph on the right represents data during the intervention season.

transfers demonstrated a similar pattern preintervention and postintervention (Fig. 4), with the time between transfers increasing toward the end of each winter season.

DISCUSSION

In this QI intervention, we saw a reduction in HHFNC usage in patients admitted to a general pediatric ward with acute viral bronchiolitis from 62% to 48% after a relatively simple intervention. This change to our pathway guided

providers to attempt an LFNC trial before the initiation of HHFNC for patients admitted to the general pediatric ward. We had hypothesized that for most patients, LFNC would be sufficient treatment, based on its highly successful use in the existing randomized trials. We tracked both compliance with the LFNC recommendation and overall HHFNC use to more clearly establish that this specific change resulted in the desired outcome. Indeed, we found that protocol compliance tracked with decreased HHFNC usage. LFNC trial adherence immediately increased to

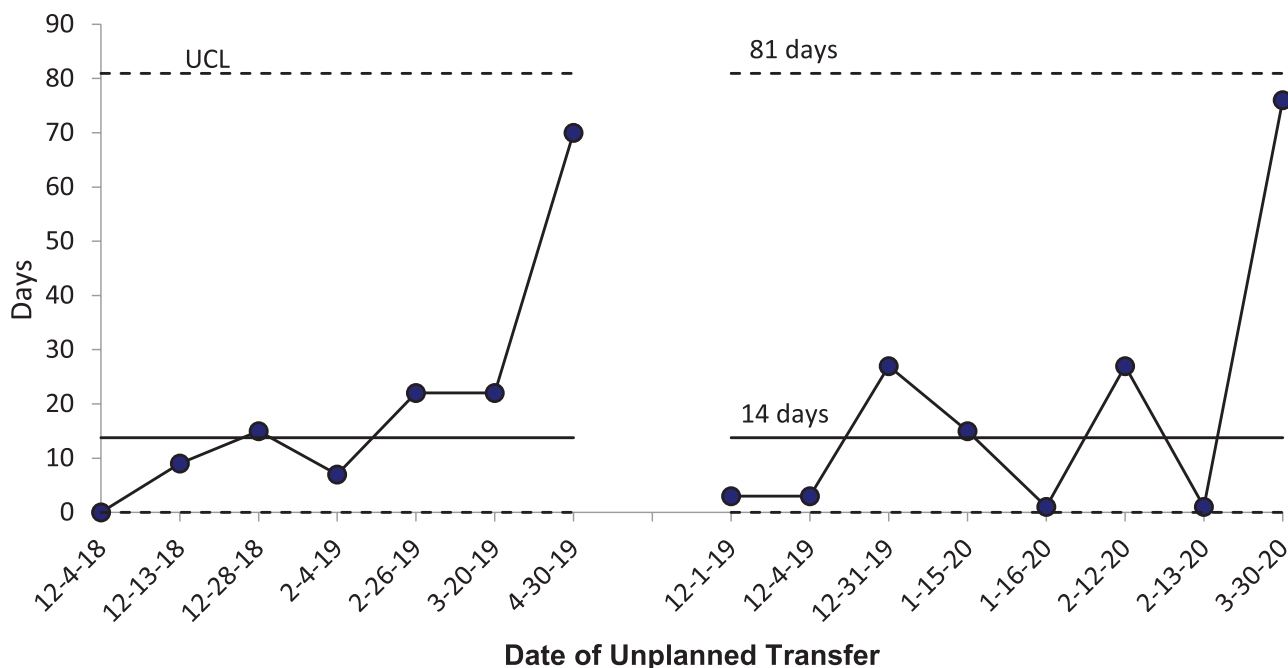


Fig. 4. Number of days between unplanned transfer to higher level of care in study population (g Chart). The graph on the left represents the immediate preintervention seasonal data. The graph on the right represents data during the intervention season.

70% after intervention and ranged between 50% and 100% for the remainder of the season. Furthermore, we noted that noncompliance with the new protocol (occurring in 11 patients) was primarily in patients under the care of per diem providers (8 of 11). These providers would not have received our educational interventions because they do not attend regular staff meetings.

Unfortunately, we fell short of our specific aim of a 50% reduction in HHFNC usage. Some of this shortfall may be related to the fact that we had to prematurely terminate our project mid-March 2020 because of the COVID-19 pandemic which dramatically decreased our hospitalization rate and likely impacted results. Furthermore, we may be overestimating our intervention's effect due to the weighting of the data toward the beginning of the season. Thus, our evidence must be considered preliminary and potentially confounded.

We hypothesized that lack of criteria for initiation and/or discontinuation of HHFNC created an environment of potential overuse of this therapy. In fact, the increasingly widespread use of HHFNC for other conditions, including asthma,¹⁸ without proven data on efficacy suggests the potential for indication creep. As noted previously, HHFNC does not improve clinical outcomes in patients with bronchiolitis and therefore indiscriminate use of this therapy has been questioned. A recent analysis evaluating the cost of providing high flow as first-line therapy compared to rescue therapy after failure of standard oxygen indicated the mean cost of bronchiolitis treatment (including intervention costs and LOS costs) was AU\$420 higher per case in the early HHFNC group compared to the rescue HHFNC group.¹⁹ The aim of our study was not

to estimate costs savings, but we speculate that a more standardized approach to HHFNC use could save a significant amount of money for a health system over time.

Our study has limitations, the most important being that we had to terminate prematurely due to a dramatic decline in hospital volume due to the COVID-19 pandemic. Thus, it is possible that HHFNC use will revert to preintervention rates, as decreased scrutiny of the guideline occurs. Furthermore, our study only includes one season as baseline and one intervention season, and therefore, our conclusions must be tempered by our knowledge that bronchiolitis severity varies annually. We did not collect data on oxygen saturation values at the time of LFNC or HHFNC initiation, since our institutional practice was to focus on respiratory effort and not a pre-specified oxygen saturation limit. Given that individual provider definitions of hypoxia may vary greatly, we may have substituted one unnecessary therapy for another by replacing HHFNC with LFNC. We also note that we need to directly engage per diem faculty to optimize the results of future QI efforts. A useful balancing measure would be rapid response transfer rate, however, due to a significant change in our institutional rapid response transfer process during this period, which was unrelated to HFNC, the data were not stable and therefore not sensitive to our intervention. Additionally, we recognize a tradeoff between HHFNC use, which allows for the use of flow with room air, and the risk of hyperoxia using 100% FiO₂ by LFNC. This area requires further study in the pediatric population. Last, although we prespecified the use of Western Electric rules for control chart interpretation, we acknowledge that other published SPC interpretation

rules require 8 rather than 7 points below the centerline to establish special cause variation, a threshold our project did not exceed due to early discontinuation.

CONCLUSIONS

To date, studies reveal that HHFNC does not alter patient-centered outcomes in mild to moderate acute viral bronchiolitis. Our QI intervention implementing a trial of standard LFNC before the initiation of HHFNC shows promise in reducing the overall use of HHFNC therapy. Future studies should focus on clear initiation and discontinuation criteria for HHFNC use in bronchiolitis.

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

REFERENCES

1. Fujjogi M, Goto T, Yasunaga H. Trends in bronchiolitis hospitalizations in the United States: 2000-2016. *Pediatrics*. 2019;144:e20192614.
2. 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:e1474–e1502.
3. Parikh K, Hall M, Teach SJ. Bronchiolitis management before and after the AAP guidelines. *Pediatrics*. 2014;133:e1–e7.
4. McCulloh RJ, Smitherman SE, Koehn KL, et al. Assessing the impact of national guidelines on the management of children hospitalized for acute bronchiolitis. *Pediatr Pulmonol*. 2014;49:688–694.
5. Tyler A, Krack P, Bakel LA, et al. Interventions to reduce over-utilized tests and treatments in bronchiolitis. *Pediatrics*. 2018;141:e20170485.
6. McKiernan C, Chua LC, Visintainer PF, et al. High flow nasal cannulae therapy in infants with bronchiolitis. *J Pediatr*. 2010;156:634–638.
7. Schibler A, Pham TM, Dunster KR, et al. Reduced intubation rates for infants after introduction of high-flow nasal prong oxygen delivery. *Intensive Care Med*. 2011;37:847–852.
8. 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;389:930–939.
9. 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;378:1121–1131.
10. Garland H, Gunz A, Miller M, et al. High-flow nasal cannula implementation has not reduced intubation rates for bronchiolitis in Canada. *Paediatr Child Health*. 2020: pxaa023.
11. 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;15:325–330.
12. de Benedictis FM. The effectiveness of high-flow oxygen therapy and the fascinating song of the sirens. *JAMA Pediatr*. 2019;173:125–126.
13. Ralston SL. High-flow nasal cannula therapy for pediatric patients with bronchiolitis: time to put the horse back in the barn. *JAMA Pediatr*. 2020;174:635–636.
14. Riese J, Porter T, Fierce J, et al. Clinical outcomes of bronchiolitis after implementation of a general ward high flow nasal cannula guideline. *Hosp Pediatr*. 2017;7:197–203.
15. Liu LL, Gallaher MM, Davis RL, et al. Use of a respiratory clinical score among different providers. *Pediatr Pulmonol*. 2004;37:243–248.
16. Langley GL, Moen R, Nolan KM, et al. *The Improvement Guide: A Practical Approach to Enhancing Organizational Performance*. 2nd ed. Jossey-Bass Publishers; 2009.
17. Wheeler TA, Davis JT, Brilli RJ. The aggregate point rule for identifying shifts on P charts and U charts. *Pediatr Qual Saf*. 2018;3:e103.
18. Baudin F, Buisson A, Vanel B, et al. Nasal high flow in management of children with status asthmaticus: a retrospective observational study. *Ann Intensive Care*. 2017;7:55.
19. Ge 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;105:975–980.