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High Flow Nasal Cannula Oxygen Therapy and Length of Stay in Bronchiolitis

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ABSTRACT

Background: Recent meta-analyses on the treatment of bronchiolitis with high flow nasal cannula oxygen therapy (HFNC) therapy suggest its utility as rescue therapy. Evidence of the effect of HFNC on length of stay (LOS) is variable. This study explored LOS and interhospital transfer to tertiary referral centres as HFNC was introduced to a peripheral paediatric unit in a metropolitan hospital. It also compared LOS associated with HFNC vs non-HFNC management overtime. **Methods:** This retrospective single centre study collected data from 2457 cases of bronchiolitis presentations over three distinct epochs; before (Epoch 1), during (Epoch 2), and after (Epoch 3) the establishment of HFNC as a routine therapy for bronchiolitis in infants attending a peripheral metropolitan hospital. **Results:** LOS overall increased with HFNC introduction, however transfer rates to tertiary referral centres did not change significantly over time. Furthermore, LOS was greater for those who received HFNC than non-HFNC (IRR of 1.83; 1.71 – 1.96; $p < 0.01$), and transfer rates were higher for patients receiving HFNC than not in both Epoch 2 and 3. **Conclusions:** Considering the now established utility of HFNC as rescue therapy, the increasing LOS and unchanged transfer rates observed with the introduction of HFNC may reflect the impact of clinician caution with slower weaning rates, particularly in a peripheral paediatric centre. Future research should investigate the role of clinician judgment in HFNC initiation and weaning.

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INTRODUCTION

Bronchiolitis is the leading cause of lower respiratory tract illness in infants less than 12 months of age [1,2], accounting for over 50% of infant admissions annually in Australia. This presentation represents a significant healthcare burden, with an estimated mean cost exceeding $17,000 per child [2,3].

Management of bronchiolitis is supportive, with oxygenation and hydration as primary therapeutic goals. Contemporary bronchiolitis treatment in Australia follows a stepwise escalation with four respiratory support modes based on hypoxia severity: standard oxygen therapy (SOT), heated-humidified high flow nasal cannula oxygen therapy (HFNC), continuous positive airway pressure, and mechanical ventilation [4,5].

The evolution of New South Wales (NSW) Health guidelines reflects the growing role of HFNC in bronchiolitis management. In 2005, prior to the widespread adoption of HFNC in general paediatrics, New South Wales state Health guidelines recommended escalation to intensive care units (ICUs) or retrieval services for severe bronchiolitis [6]. By 2012, updated guidelines recommended consideration of HFNC in cases of severe bronchiolitis [7]. The 2018 iteration further expanded this recommendation, advising the consideration of HFNC in infants with moderate or severe bronchiolitis whose saturations of oxygen remained persistently below 92% with at least moderate chest wall retractions [8].

Despite evolving guidelines and limited robust evidence supporting its efficacy during the early 2000s, the use of HFNC therapy in ICUs across Australia and New Zealand increased by 72.6% between 2002 and 2014 [9]. This trend likely reflects individual clinician-driven decision-making in the management of bronchiolitis. Subsequent studies had indicated that early initiation of HFNC may reduce the need for non-invasive ventilation (NIV) in infants with bronchiolitis [10]. Consequently, HFNC for management of bronchiolitis had become more widespread in inpatient paediatric units [5]. The ease of HFNC application in peripheral emergency departments (EDs) and wards, compared to NIV and invasive ventilation—which necessitate interfacility transfers—has further contributed to its widespread use.

Given the widespread adoption of HFNC therapy in peripheral paediatric settings, it is essential to evaluate its impact on clinical outcomes such as length of stay (LOS) and interfacility transfer rates. Current evidence on these outcomes remains limited, particularly in non-tertiary care environments. Hence, this study hypothesises that the implementation of HFNC as a therapy option for infants with bronchiolitis in the peripheral hospital settings will be associated with a reduction in interfacility transfer rates and increase in hospital LOS overall across time.

The aims of this study were to; 1. Compare overall bronchiolitis transfer rates over time, as HFNC therapy became locally available; 2. Compare overall bronchiolitis LOS over time, as HFNC therapy became locally available; and 3. Compare the LOS in inpatients with bronchiolitis who had and had not received HFNC, as a baseline to aid in the interpretation of trends.

METHODS

Subjects and Measurements

This retrospective single centre study collected data from presentations coded as 'acute bronchiolitis' (ICD J21.9) at the Children's Ward at Mount Druitt Hospital, a mixed adult and paediatric peripheral hospital in peripheral-metropolitan Sydney, 20 kms from the closest tertiary children's hospital. All patients were aged less than 12 months. Data was collected from three distinct epochs: Epoch 1 – 2004 to 2008 (no HFNC); Epoch 2 – September 2014 to November 2016 (HFNC available); Epoch 3 – December 2016 to December 2018 (HFNC available). These periods were selected to encompass time before HFNC introduction in 2009 (Epoch 1), prior to widespread use (Epoch 2), and post widespread use with a higher flow limit (Epoch 3). HFNC maximum flow rates were set pursuant to local guidelines at the time. The 2014 protocol specified a starting or Initial flow rate of 0.5-1L/kg, starting FiO2 of 40%, and maximum flow rate of 12L/min. The 2016 protocol specified an initial flow rate of 1L/kg, starting FiO2 of 40%, and maximum flow rate of 25L/min. The differences in maximal HFNC flow rates between Epoch 2 and Epoch 3, with Epoch 3 representing optimisation of HFNC protocol, allows further commentary of HFNC as a

bronchiolitis management tool. Data between 2009-2013 was excluded due to concerns regarding coding inaccuracies during the local adoption of HFNC. This exclusion period encompasses the 2012 guideline update [7], where adoption of HFNC in the peripheral centre would have been limited by equipment availability and clinician familiarity.

We extracted HFNC use, LOS, age, sex, admission and discharge dates, and hospital transfer status. Transfer to tertiary referral hospitals occurred only with consultant level input, there were otherwise no set criteria for transfer.

Ethical considerations

Research was undertaken as approved by Westmead Scientific Advisory Quality Assurance Committee and the Secretary of the Western Sydney Local Health District Human Research Ethics Committee (2002-12 QA).

Statistical analysis

Hypothesis testing was undertaken in Stata SE Version 14.2 with a two-sided alternative and a significance level of 0.05. Poisson regression models adjusted for age and sex as possible confounding factors. A secondary model over Epochs 2 and 3 adjusted for HFNC. The incidence rate ratio (IRR) quantifies the difference in estimated LOS between two groups.

RESULTS

Demographic Characteristics

We analysed 2,457 presentations (892 F) bronchiolitis presentations of infants under 12 months. The introduction of HFNC is clearly demarcated with no usage in Epoch 1 (Table 1). Across the 3 epochs the median age remained stable (157 days, 152 days, and 167 days respectively); and the sex ratio fluctuated without significant changes (Table 1). Notably, HFNC therapy use increased over each time epoch (Table 1), 0.0% bronchiolitis cases received HFNC in Epoch 1, 24.7% cases received HFNC in Epoch 2, 32.2% cases received HFNC in Epoch 3.

Transfer Rates: Characteristics by Epoch

Transfer rates fluctuated over time, with no statistically significant difference in transfer rates across the three epochs (Table 1).

Table 1. Characteristics by Epoch

	Epoch 1: 2004 to 2008 (n = 1,161)	Epoch 2: September 2014 to November 2016 (n = 693)	Epoch 3: December 2016 to December 2018 (n = 603)	P value
Age (Days)	Median: 157 IQR: 85 – 240	Median: 152 IQR: 83 – 234	Median: 167 IQR: 85 – 253	0.11
Sex	M: 61.1% (709) F: 38.9% (452)	M 65.8% (456) F: 34.2% (237)	M: 66.3% (400) F: 33.7% (203)	0.04
Transferred	2.9% (34)	4.5% (31)	3.0% (18)	0.19
HFNC	0.0% (0)	24.7% (171)	32.2% (194)	<0.01
Length of Stay (Days)	Median: 1.76 IQR: 0.97 – 2.95	Median: 1.87 IQR: 1.02 – 3.30	Median: 2.10 IQR: 1.17 – 3.13	<0.01

*M: Male, F: Female, IQR: Interquartile range, HFNC: high flow nasal cannula

LOS: Characteristics by Epoch

The median LOS of the total bronchiolitis presentations was greater in Epoch 2 and 3 relatives to Epoch 1 (Table 2). Patients in Epoch 2 had an IRR of 1.14 (1.07 – 1.21; $p < 0.01$) compared to Epoch 1. Patients in Epoch 3 had an IRR of 1.18 (1.11 – 1.25; $p < 0.01$) compared to Epoch 2. Hence, LOS increased across the three time periods.

LOS and Transfer Rates: HFNC vs non-HFNC

In both Epoch 2 and 3, the transfer rate was higher for patients that received HFNC than did not (Table 2). Furthermore, in both Epochs 2 and 3, LOS was greater for those that received HFNC (Table 2). Combined patients that received HFNC had an IRR of 1.83 (1.71 – 1.96; $p < 0.01$), hence 83% longer hospital stay than their counterparts. Note Epoch 1 is not analysed here as HFNC was not introduced at this time.

Table 2. HFNC vs non-HFNC

	Epoch 2			Epoch 3		
	HFNC (n = 171)	No HFNC (n = 522)	P value	HFNC (n = 194)	No HFNC (n = 409)	P value
Age (Days)	141 (81 – 220)	159 (84 – 242)	0.06	182 (90 – 265)	164 (84 – 248)	0.13
Sex	M: 63.2% (108) F: 36.8% (63)	M: 66.7% (348) F: 33.3% (174)	0.41	M: 69.1% (134) F: 30.9% (60)	M: 65.0% (266) F: 35.0% (143)	0.36
Transferred	14.0% (24)	1.3% (7)	<0.01	6.2% (12)	1.5% (6)	0.01
Length of Stay (Days)	3.85 (2.53 – 5.21)	1.64 (0.95 – 2.40)	<0.01	3.13 (2.47 – 4.65)	1.67 (1.01 – 2.41)	<0.01

*M: Male, F: Female, HFNC: high flow nasal cannula

DISCUSSION

This study of bronchiolitis presentation and management found that patients in HFNC group had a higher LOS compared to the non-HFNC group and that total LOS increased across time, however transfer rates did not change over time. This presents an unexpected finding.

The increased LOS in HFNC compared to non-HFNC may reflect that HFNC is not an effective therapy or that confounders such as severity of illness are at play. If as directed by guidelines HFNC was applied to more critical presentations then LOS may be driven by the time taken for pathology to resolve, which in itself may involve mechanisms more persistent than those not requiring such oxygen therapy in the first instance. Limited by the retrospective nature, this study did not collect data on severity as the focus was not to determine the effectiveness of HFNC in managing pathology but to assess the impact of its introduction on clinical outcomes in a secondary centre. Since our study period, more recent reviews and meta-analyses on bronchiolitis treatment with HFNC have shown either a decrease in, or no, difference in lengths of stay with considerable heterogeneity [11-13]. Furthermore, the PARIS II Trial demonstrated no improvement to LOS with HFNC [14]. Of note, the PARIS II trial was conducted in Australian tertiary and peripheral settings, suggesting relevance for our study population. Across studies, there was also wide variation in the definitions of "treatment failure" with HFNC therapy which included changes in physiological parameters, the use of a clinical score, and escalation to a higher level of care including ICU [11-14].

Particularly interesting is our finding that across time with increasing utilisation of HFNC in our peripheral centre, LOS increased without reduction in transfer rates. This unexpected finding may reflect the impact of uncontrolled-for confounders, such as clinician driven caution in the peripheral setting. Due to a lack of resources in peripheral setting, including no on-site Paediatric Intensive Care Unit (PICU), a single paediatric registrar and no anaesthetic back up after hours, there may be clinician tendency towards wariness resultant in slower weaning and a lower threshold for transfers, and eagerness to commence resultant in high uptake of therapy. Though there were local guidelines on weaning and commencement practices during Epochs 2 and 3, this may have been subject to varying interpretations. One Australian study suggested that despite an objective understanding of the guidelines, the commencement of HFNC management may be related not just to patient factors but also to clinician factors such as emotion, influences of nursing colleagues and families [15]. Additionally, potential negative effects such as increases in LOS, health costs [16] and discomfort [15] may be relatively neglected. Contemporary guidelines across three states, including NSW, recommend low flow oxygen for oxygen saturation of less than 90% [17]. HFNC is more specifically indicated for those who have "severe/life threatening" illness with "ICU review," and should be considered for hypoxaemia, tachycardia, tachypnoea and/or respiratory distress after 2–3 hours of treatment [17]. Reduction in clinical decision variability can be achieved but requires significant investment of resources [18].

Conversely, another possible reason to account for no changes to transfer rates may potentially be attributed to the clinician's anxiety regarding the complications of HFNC itself (for example pneumothorax) prompting transfers, although we note that studies have consistently demonstrated its safety [10,19].

The primary limitations of this study are attributable to its single-site retrospective design. Key confounders of severe bronchiolitis such as prematurity or chronic lung disease could not be controlled, however, the large data set partially mitigates against this. Additionally, this study could not capture potential cases transferred out directly from ED without administrative coding as an inpatient admission. Finally, this study did not assess the clinical decision to transfer at an individual patient level. However, all transfer decisions in the studied unit are made at consultant level only and may be multifactorial beyond clinical signs including chronic conditions, local staffing/resourcing and parental concern.

CONCLUSIONS

This study found that in one peripheral centre the introduction of HFNC increased LOS without decreasing interhospital transfer rates. This highlights gaps in understanding, specifically regarding role of clinician judgment especially in the application of new guidelines and in the context of a peripheral centre. The importance of specifying both initiation and weaning pathways for HFNC within guidelines, noting potential differences in approach between tertiary and peripheral centres.

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None.

CONFLICT OF INTEREST

The authors have no conflict of interest relevant to this article.

DATA AVAILABILITY

The datasets analysed in this study are not publicly available due NSW Health Privacy policies but are available to authorised requesters on reasonable requests via NSW Health.

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