7-9-2020

Utilizing High Flow Oxygen Therapy In Infants With Bronchiolitis

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BSN, University of Missouri-Saint Louis, 2016

A Dissertation Submitted to The Graduate School at the University of Missouri-St. Louis
in partial fulfillment of the requirements for the degree
Doctor of Nursing Practice

August 2020

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Abstract

Problem Bronchiolitis is the leading diagnosis of hospitalizations for children under one-year. The purpose of this study was to evaluate the effectiveness of supportive high-flow oxygen (HFO) therapy for infant patients requiring more than 2L/min nasal cannula (NC).

Methods An observational, descriptive design with convenience sampling of infants aged one-year or less, hospitalized with bronchiolitis and requiring HFO therapy. Comparisons were done between 2019 when no HFO was allowed on the general unit and in 2020 when HFO was allowed.

Results Of 28 patients (N = 28), 13 (n = 13) were in the 2019 cohort and 15 (n = 15) in 2020. A Fischer's exact test indicated a general unit admission in 2020 was not likely to result in a pediatric intensive care unit (PICU) transfer. Significant positive associations were evident between length of oxygen therapy and length of stay (LOS) in 2019 (r_p = 0.95, p<.001) and 2020 (r_p = 1.00, p<.001); length of oxygen therapy and length of HFO therapy (r_p = 0.77, p = .015); and LOS and length of HFO therapy (r_p = 0.80, p = .010) in 2020. No differences emerged between rates of initial PICU admissions, PICU transfers, length of oxygen therapy, length of HFO therapy, PICU LOS, or LOS between cohorts.

Implications for Practice Use of HFO therapy on the general unit was associated with decreases in frequency of PICU transfers and initial admissions, but no changes occurred in length of oxygen therapy, length of HFO therapy, PICU LOS, or total LOS.

Keywords: *2019 cohort, 2020 cohort, bronchiolitis, high-flow oxygen, length of stay, low-flow oxygen, nasal cannula, pediatric intensive care unit, pediatric unit, transfers*

Utilizing High Flow Oxygen Therapy In Infants With Bronchiolitis

The American Academy of Pediatrics (AAP) defines bronchiolitis as a viral illness involving the lower airways resulting in acute inflammation and swelling, an overproduction of mucous, and destruction of epithelial cells coating the inner lining of airways (Ralston et al., 2014). The etiology of bronchiolitis is attributed to many respiratory viruses, with the most frequent infections occurring between the months of November through April (Ralston et al., 2014).

Bronchiolitis is the leading diagnosis for pediatric inpatient hospitalizations for children under a year of age, contributing to a persistent burden of disease and risk of rapid physiologic deterioration (Ralston et al., 2014). Consequently, one in every eight pediatric patients hospitalized for bronchiolitis requires admission to the PICU for HFO delivery, continuous positive airway pressure (CPAP) or other means of supportive respiratory therapy (Schlapbach et al., 2017). Furthermore, costs associated with inpatient bronchiolitis-related care have exceeded $1.73 billion per year with greater than 100,000 pediatric hospitalizations per year (Schlapbach et al., 2017; Ralston et al., 2014). Children under one year of age constituted the highest percentage of overall costs (52.9%) and volume (67.9%) of hospital stays in 2016 (Moore, Freeman, & Jiang, 2019; Douchette et al., 2016).

Current clinical practice guidelines have recommended supportive treatment only for bronchiolitis care (Ralston et al., 2014). Modes of inpatient bronchiolitis supportive treatment ranges from low flow oxygen (LFO) therapy, HFO therapy, CPAP, or the more invasive treatments of intubation and mechanical ventilation. While LFO therapy may be effective for milder cases, more severe cases of bronchiolitis may be effectively treated

with the use of HFO therapy or heated and humidified high flow (HHHF) therapy, a subset of HFO therapy.

At a suburban, Midwestern pediatric hospital, prior practice was infants one year or younger on the general pediatric unit requiring more than the maximum respiratory support, defined as more than 2L/min with NC, to be admitted to the PICU. This creates potential for over-utilization of PICU resources and increased costs for patients who may be capable of receiving safe, effective care on a general pediatric unit. As part of a quality improvement (QI) initiative, in September 2019, a new process change included the admission of infants to the general pediatric unit for supportive oxygen therapy up to 6L/min NC or up to 50% fraction of inspired oxygen (FiO_2) with a venturi mask. At the clinical site of interest, the prior maximum respiratory support on the general pediatric unit in 2019 was defined as oxygen delivery of up to 2L/min NC or up to 50% oxygen via mask. The purpose of this QI initiative was to evaluate the effectiveness of an increased allowance of supportive oxygen therapy for infant patients requiring up to 6L/min NC on a general pediatric unit. The aim of this project was to reduce PICU admissions for supportive HFO therapy of infants with bronchiolitis by 15%. The outcome measures of interest were the number of initial general unit admissions, the number of initial PICU admissions, number of PICU transfers, total length of supportive oxygen therapy, total length of HFO therapy, PICU LOS, and the total hospital LOS. The question for study was: in hospitalized infants under one-year of age diagnosed with bronchiolitis, what is the effect of general unit-based HFO therapy compared to PICU-based HFO therapy on PICU transfers, PICU admissions, length of supportive oxygen therapy, length of HFO therapy, PICU LOS, and total hospital LOS, during the peak of bronchiolitis season?

Review of Literature

The databases searched for this review were the Cochrane Database of Systematic Reviews, CINAHL, Google Scholar, Medline, and national health care databases, such as the Agency for Healthcare Research and Quality (AHRQ), Centers for Disease Control and Prevention (CDC), and the Healthcare Cost and Utilization Project (HCUP). Key search terms were *picu, pediatric, low flow, high flow, high flow therapy, pediatric floor, general floor, bronchiolitis,* and *infant,* using the Boolean operators AND and OR. The literature review included all publications from 2014 to 2019, full-text and written in English. Publications were excluded if the principal objectives were to examine outpatient or home therapy treatments, premature infants, and children with a history of any chronic medical condition. In addition, an ancestry method was used from relevant publications. The search yielded nine publications, including one systematic review, two randomized control trials (RCT), one case-control study, and four retrospective studies of which three contained a pre- and post-intervention component. The following themes emerged from the evidence regarding bronchiolitis management: effectiveness of high flow oxygen therapy, and setting-dependent differences in LOS and costs.

The effectiveness of HFO therapy for bronchiolitis management was featured prominently in several publications. A study by Mayfield, Bogossian, O'Malley, and Schibler (2014) discovered significant decreases in heart rate (HR) and respiratory rate (RR) for infants treated with HFO therapy. The authors' definition of HFO therapy was a flow rate greater than 2L/kg/min per NC (max 10L/min). Their case-control study found patients on HFO on the general pediatric unit were four times less likely to require transfer to the PICU as compared to patients on LFO therapy (Mayfield et al., 2014).

Infants who responded to HFO displayed a statistically significant decrease ($p<0.002$) in HR and RR in comparison to patients on LFO therapy (Mayfield et al., 2014). Limitations of this study included being a case-control study, non-randomization of patients, and small sample size ($N=94$) (Mayfield et al., 2014). Mayfield et al. (2014) concluded patients on HFO therapy could be safely managed on a general pediatric floor; however, the authors emphasized the need for future RCTs to strengthen evidence for the safe use of HFO therapy on a general pediatric unit.

Kepreotes et al., (2017) commenced a RCT of children under 2 years of age diagnosed with bronchiolitis. Patients were randomly assigned to either a standard, low flow cold oxygen therapy (LFCO) (max 2L/min NC) or a high flow warmed humidified oxygen (HFWHO) therapy, defined as 1L/kg/min NC to a max of 20L/min NC (Kepreotes et al., 2017). They found twice as many patients in the LFCO therapy group suffered treatment failure, defined as requirement of higher level of care, when compared to patients on HFWHO (33 [LFCO] vs 14 [HFWHO], $p=0.0016$). More HFWHO patients remained failure-free after 24-hours (90% [HFWHO] vs 60% [LFCO], $p<0.0001$) versus LFCO patients (Kepreotes et al., 2017). Additionally, two-thirds of the LFCO therapy patients demonstrated improvement when placed on HFWHO and avoided a PICU admission (Kepreotes et al., 2017). This RCT offered compelling support for the effectiveness in HFO therapy improving a patient's clinical outcome.

Likewise, Franklin et al. (2018) conducted a RCT of infants receiving either LFO (up to 2L/min NC) or HFO therapy (2L/kg/min NC) and studied how many patients in both groups experienced treatment failure. Their results demonstrated a statistically significant difference in patients who required treatment escalation between groups (167

[LFO] vs 87 [HFO], $p<0.001$) (Franklin et al., 2018). Of 167 patients initially receiving LFO, 102 of the 167 patients responded well to HFO therapy when therapy was escalated (Franklin et al., 2018). The strengths of Franklin et al. (2018) study included their RCT design, multi-center inclusion, and a large sample size (N=1,472). However, the Franklin et al. (2018) study was limited in that HFO therapy only occurred within the PICU setting; therefore, a comparison of HFO supportive care between the general floor and PICU could not be determined.

Beggs, Wong, Kaul, Odgen, and Walters (2014) performed a systematic review to assess for the effectiveness of HFO therapy compared to other types of respiratory interventions (i.e., CPAP, oxygen tent, LFO, and non-invasive ventilation) in patients with a bronchiolitis diagnosis. Only one published RCT met inclusive criteria (Hilliard et al., 2012 cited in Beggs, et al., 2014). Hilliard et al., (2012) study considered HFO therapy as oxygen rates greater than 4L/min NC. No statistical difference was observed in LOS between LFO and HFO therapy (164 hours [LFO] vs 162 hours [HFO], p=0.7), or total length of oxygen use (117 hours [LFO] vs 80 hours [HFO], p=0.32). Although well designed, this RCT had only a small sample size (N=19) and was deficient in documented clinical outcomes, thus limiting the strength of the evidence for the effectiveness of HFO use for bronchiolitis management (Beggs et al., 2014).

Infants with bronchiolitis treated with HFO may experience a decreased LOS in the hospital. Riese, Fierce, Riese, and Alverson (2015) demonstrated a substantial decrease in LOS for patients on high-flow nasal cannula (HFNC) therapy attributed to a policy change. A retrospective, non-randomized, pre- and post-intervention study followed infants under 2 years of age utilizing HFNC treatment before and after the

policy change. The old policy did not allow for the initiation or continuation of HFO on the general pediatric unit, but the new change allowed patients on the general pediatric unit to be started or continued on HFO (Riese et al., 2015). Maximum flow rate for infants less than six months of age was up to 8L/min NC, infants six to 18 months of age up to 12L/min NC, and toddlers 18 to 24 months of age up to 15L/min NC. Outcome measures included LOS, total hospital costs and readmission rates, which were then compared between the populations of interest (Riese et al., 2015). In HFO patients treated on the general unit, a statistically significant decrease in LOS of one day ($p<0.001$) and its associated hospital charges ($2,920, $p<0.001$) was discovered (Riese et al., 2015). This investigation was the first to examine the relationship between HFNC use in bronchiolitis patients and LOS. Limitations of the study included a single-site locale and difficulty controlling for variables, such as seasonal variation or level of illness severity. Regardless, the authors concluded bronchiolitis patients on HFNC therapy demonstrated lower rates of LOS and costs; but emphasized additional investigations on patient outcomes to strengthen the argument for the safe utilization of HFO therapy on the general floor (Riese et al., 2015).

A repeat quasi-experimental study by Riese et al. (2017) was performed as a follow-up to their first study for validation. LOS, PICU transfers, and readmission rates in patients on HFNC therapy were studied (Riese et al., 2017). The same age-dependent oxygen flow rates initiated previously were continued from the initial study. The 2017 inquiry included a larger cohort of patients evaluated (N=576) than the 2015 study (N=290). In HFO patients treated on the general unit, a statistically significant decrease in unadjusted days on HFNC ($p<0.001$) and mean LOS ($p=0.02$) was discovered, consistent

with their first study findings (Riese et al., 2017). Hence, HFO for infants with bronchiolitis was clinically beneficial and cost-effective.

Multiple studies have examined the costs associated with HFO therapy (Collins, Chan, Roberts, Wren, & Wright, 2017; Heikkila, Forma, & Korppi, 2014; Riese et al., 2015). Collins et al. (2017) quasi-experimental study assessed costs of PICU HFO and general pediatric unit HFO via a simulated care model. Infants 30-90 days old could receive up to 4L/min NC and patients 91 days to 2 years old could receive up to 6L/min NC. Patients who received HFO therapy in the PICU accrued a 10% higher cost of care when compared to patients who received care on the general pediatric unit (Collins et al., 2017). While these costs were direct patient costs, incidental expenses, i.e. staff and equipment costs were not itemized (Collins et al., 2017). Similarly, Heikkila et al. (2014) performed a retrospective study to identify aspects of bronchiolitis care associated with high hospital costs but differentiated these costs contingent upon setting. The results established a strong positive correlation (r=0.960, p<0.001) of overall costs to total LOS and length of PICU stay (Heikkila et al., 2014). Moreover, the cost per patient per day in the PICU for bronchiolitis care was nearly four times higher than patients receiving bronchiolitis care on the general pediatric floor (Heikkila et al., 2014). However, Heikkila et al. (2014) study did not differentiate type of treatment modality used or if treatment modality was consistent between the PICU and the general unit. Finally, Schlapbach et al. (2017) aimed to measure admission rates, direct costs and patient outcomes before and after the widespread use of HFO in a multicenter site study spanning ICUs in two countries. The authors defined HFO therapy as a flow rate greater than 1L/min NC. They discovered bronchiolitis was the primary diagnosis for admission to the ICU during the

13-year time period, and the rates of ICU admission rose with the use of HFO (Schlapbach et al., 2017). After widespread HFO initiation, HFO usage increased to 72% with a subsequent decrease in the utilization of non-invasive ventilation (NIV), intubation and mechanical ventilation (Schlapbach et al., 2017). While the average hospital LOS decreased post-HFO usage (12.47 to 9.13 days, $p<0.001$), total direct costs more than tripled (Schlapbach et al., 2017). The study's implications demonstrated treatment for bronchiolitis accounted for high hospital costs in the ICU setting; however, the use of HFO demonstrated a cost savings when delivered on a general pediatric unit and an overall decrease in LOS.

HFO therapy for bronchiolitis has been reported to provide safe and effective care (Mayfield et al., 2014; Franklin et al., 2018; Riese et al., 2015; Riese et al., 2017; Kepreotes et al., 2017) regardless of location. While some analyses found decreases in LOS (Schlapbach et al., 2017; Riese et al., 2015; Riese et al., 2017), others did not establish a link between HFO therapy and decreased LOS (Beggs et al., 2014; Mayfield et al., 2014). With such variation, current practice guidelines need further research focused on patient-centered outcomes in bronchiolitis treatment (Ralston et al., 2014).

The implementation of HFO therapy reduced the frequency of care escalations, decreased associated healthcare costs and hospital LOS. Bronchiolitis care on a general pediatric unit may produce a cost savings without compromising safety in the care delivered (Collins et al., 2017; Heikkila et al., 2014). In summary, despite most of the studies in this review demonstrating relatively safe, efficacious, and cost-effective care of pediatric patients who received HFO therapy on the general unit, there are few published studies of a strong design and subsequently, no major changes in current clinical practice

have occurred. Further studies regarding HFO therapy for bronchiolitis delivered on a general pediatric unit when compared to PICU-based care are needed.

A large, Midwestern, suburban medical center with a pediatric hospital previously admitted infants under one year of age with bronchiolitis requiring more than 2L/min NC of supportive oxygen therapy to the PICU. Based upon equipment availability, a process change was implemented to admit infants on HFO to the general unit instead of the PICU. This pilot test-of-change employed Deming's Plan-Do-Study-Act (PDSA) cycle for initiating and measuring the change (The W. Edwards Deming Institute, 2019).

Method

Design

The study was an observational, descriptive design. The method of evaluation was a retrospective medical record review before (2019) and after (2020) a process change during the bronchiolitis season. The 2019 process required bronchiolitis patients needing a higher amount than standard supportive oxygen therapy (greater than 2L/min NC) to be admitted and monitored in the PICU. The 2020 process change included admission of patients in need of a higher amount of supportive oxygen therapy, up to 6L/min NC to the general pediatric unit. This QI initiative evaluated patients over a three month period, from February 1st, 2019 and 2020 through April 30th, 2019 and 2020, during the peak of the bronchiolitis season.

Setting

The setting was a suburban, Midwestern children's hospital PICU and general pediatric unit located within a large medical center. The children's hospital employs a team of pediatric specialists in over 30 subspecialties, comprising the only 12-bed PICU

in the suburban area, along with a 48-bed general pediatric inpatient unit and a separate pediatric emergency department (ED).

Sample

This was a convenience sample of infants under one-year of age with a diagnosis of bronchiolitis admitted to either the general pediatric unit or the PICU. Inclusion criteria were: 1) a primary or secondary diagnosis of bronchiolitis or wheezing-associated respiratory infection (WARI); and, 2) requirement of HFO therapy more than 2L/min NC. Exclusion criteria were: 1) prematurity (before 37 weeks' gestation); 2) a chronic health condition that affected the pulmonary system; 3) requirement of equal to or less than 2L/min NC supportive oxygen therapy; or 4) requirement of CPAP, non-invasive ventilation, or intubation.

Approval Process

Approval was obtained from the pediatric administration at the medical center. Additional approvals from the doctor of nursing practice (DNP) committee, the medical center's institutional review board (IRB) and the university's IRB were acquired. Risks of this study were potential breaches of patient confidentiality; however, this was a retrospective medical record review removing all patient identifiers to minimize this risk. Benefits of the project included knowledge gained in resource utilization and in patient care of infants with bronchiolitis.

Data Collection/Analysis

Collected data included the demographics of gender, race, and age. In addition, the number of initial general floor admissions, the number of initial PICU admissions, the number of PICU transfers, total length of supportive oxygen therapy, length of HFO

therapy, PICU LOS, and the total hospital LOS was recorded. All data was de-identified and coded as 2019 cohort data and 2020 cohort data. Descriptive statistics were used, and the inferential statistics of Fischer's exact test, Pearson *r* correlation, and *t*-Tests were completed. Intellectus Statistics (http://analyze.intellectusstatistics.com/) was used. Results were considered significant at the .05 level.

Process

A team of stakeholders consisting of pediatric hospitalists, intensivists and respiratory therapists was convened to address resource utilization for hospitalized infants with bronchiolitis. After examining available respiratory equipment, a decision was made to pilot the implementation of the use of HFO therapy via standard NC on the general pediatric unit with the aim of improving patient outcomes and total hospital LOS.

Results

A total of 80 potential subjects were identified with a bronchiolitis diagnosis during the 2019 period. Of those, 13 (N = 13) met inclusion criteria for study. The predominant gender in the 2019 cohort was male (n = 10, 77%) with three patients being female (n = 3, 23%). The predominant race was Caucasian (n = 12, 92.3%) with one African-American patient (n = 1, 7.7%). The mean age of patients in the 2019 cohort was 9.8 weeks (SD = 5.6). One patient was 2-weeks old (7.7%); one patient was 4-weeks old (7.7%); two patients were 5-weeks old (15.4%); one patient was 7-weeks old (7.7%); three patients were 8-weeks old (23%); one patient was 12-weeks old (7.7%); three patients were 16-weeks old (23%); and one patient was 20-weeks old (7.7%).

A total of 46 potential subjects were identified with a bronchiolitis diagnosis during the 2020 time frame. Of those, 15 (N = 15) met inclusion criteria for study. The

predominant gender in the 2020 cohort was female (*n* = 10, 66.7%), with five patients being male (33.3%). The predominant race was Caucasian (*n* = 10, 66.7%) with three African-American patients (20%) and two Asian-Indian patients (13.3%). The mean age of patients in the 2020 cohort was 24.9 weeks (*SD* = 18.2). One patient was 3-weeks old (6.6%); one patient was 4-weeks old (6.6%); one patient was 5-weeks old (6.6.%); one patient was 6-weeks old (6.6%); one patient was 7-weeks old (6.6%); one patient was 8-weeks old (6.6%); one patient was 16-weeks old (6.6%); one patient was 28-weeks old (6.6%); one patient was 32-weeks old (6.6%); one patient was 40-weeks old (6.6%); four patients were 44-weeks old (26.6%); and one patient was 48-weeks old (6.6%).

In the 2019 cohort, six patients (46%) were initially admitted to the general unit, and seven (54%) were initially admitted to the PICU. Ultimately, all six patients (100%) initially admitted to the general unit were transferred to the PICU for escalation of HFO therapy. In the 2020 cohort, 11 patients (73%) were initially admitted to the general floor, and four (27%) were initially admitted to the PICU. Five patients (45.5%) initially admitted to the general floor were transferred to the PICU for escalation of HFO therapy (Appendix A).

The patients in the 2019 cohort experienced a mean of 102.54 hours (*SD* = 66.93) on supportive oxygen therapy, and a mean of 42.35 hours (*SD* = 23.82) for those on HFO therapy in the PICU. Mean PICU LOS was 54.85 hours (*SD* = 32.49), and mean total hospitalized LOS was 134.81 hours (*SD* = 103.45). The patients in the 2020 cohort experienced a mean of 105.13 hours (*SD* = 90.24) on supportive oxygen therapy, with a mean of 56.87 hours (*SD* = 64.12) for those on HFO therapy either on the general unit or

in the PICU. The mean PICU LOS was 89.56 hours (*SD* = 75.52), and mean total hospitalized LOS was 119.43 (*SD* = 93.84).

A Fischer's Exact Test was used to examine if general unit admissions and PICU transfers were independent of each other in the 2020 cohort. The initial general unit admission rate in the 2020 cohort was 11 but five were transferred to the PICU (p = .231). Hence, in 2020, a general unit admission was not likely to result in a transfer to the PICU (Appendix B). A nonparametric test was unable to be performed on the 2019 cohort data due to the perfect collinearity of the data.

A Pearson *r* correlation was conducted to examine the relationship between supportive oxygen therapy and total hospitalized LOS. A very strong relationship between length of supportive oxygen therapy and total hospitalized LOS in the 2019 cohort (r_p = 0.95, p<.001) was found. No other relationships were evident. In addition, a perfect, direct relationship between length of oxygen therapy and total hospitalized LOS was established in the 2020 cohort (r_p = 1.00, p< .001). Also in the 2020 cohort, a very strong relationship was established between length of supportive oxygen therapy and length of HFO therapy (r_p = 0.77, p = .015), and a very strong relationship was established between total hospitalized LOS and length of HFO therapy (r_p = 0.80, p = .010). No other relationships were evident (Appendix C).

The independent samples paired *t*-test was performed to evaluate differences in length of supportive oxygen therapy, HFO therapy, PICU LOS, and total hospitalized LOS between the 2019 and 2020 cohorts. The mean length of supportive oxygen therapy increased slightly from 102.54 hours (*SD* = 66.93) in the 2019 cohort to 105.13 hours (*SD* = 90.24) in the 2020 cohort. The difference between means was not statistically

significant at the .05 level (t = 0.09, d = 0.03, p = .933). The mean length of HFO therapy increased from 42.35 hours (SD = 23.82) in the 2019 cohort to 56.87 hours (SD = 64.12) in the 2020 cohort. The difference between means was not statistically significant at the .05 level (t = 0.77, d = 0.30, p = .448). The mean PICU LOS increased from 54.85 hours (SD = 32.49) in the 2019 cohort to 89.56 hours (SD = 75.52) in the 2020 cohort. The difference between means was not statistically significant at the .05 level (t = 1.48, d = 0.60, p = .154). The mean total LOS decreased from 134.81 hours (SD = 103.45) in the 2019 cohort to 119.43 hours (SD = 93.84) in the 2020 cohort. The difference between means was not statistically significant at the .05 level (t = -0.41, d = 0.16, p = .683) (Appendix D). The length of supportive oxygen therapy, length of HFO therapy, PICU LOS, and hospitalized LOS were independent of each other.

Discussion

The results of general unit-based HFO therapy for bronchiolitis care demonstrated no significant differences in length of supportive oxygen therapy, length of HFO therapy, or PICU LOS when compared to the former PICU focused HFO therapy based care. Although a significant difference among rate of PICU transfers, rate of initial PICU admits, and total hospital LOS was not established between groups, the frequency of initial PICU transfers decreased by 54.5%, the frequency of initial PICU admissions decreased by 27%, and the total hospital LOS decreased by 15 hours, which is clinically significant.

A strength of this study was the homogeneity of sample sizes between the two cohorts for comparison. There were several limitations to this project, including the utilization of a non-randomized design at a single site of study which restricted the ability

to control for confounding variables (e.g., seasonability, viral trends, overlapping diagnoses, or unknown patient factors). Likewise, the homogeneity of the sample patients' characteristics limited the generalizability of the results. A decrease in the number of potential subjects in the 2020 cohort could be attributed to the COVID-19 pandemic which began in March 2020. This study's clinical site experienced a record low number of pediatric admissions in early 2020 because daycares were closed, and people practiced social distancing, effectively eliminating the transmission of many respiratory viruses. In addition, patients in the 2020 cohort did not receive HFO therapy via the same delivery system as patients in the 2019 cohort. Due to equipment constraints, the 2020 cohort received HFO therapy via a standard NC and oxygen bubbler bottle, rather than the 2019 cohort, who received HFO therapy via heaters and a larger bore Optiflow circuit (increased flow rates, higher levels of humidity, and heat). This change in delivery system could account for the results not demonstrating a difference in length of supportive oxygen therapy. Further research is recommended with utilization of a more diverse sample. Larger sample sizes and studies that encompass the entire bronchiolitis season are also recommended to further strengthen results. Investigations on the effects of HFO use on physiologic factors (HR, RR, SpO2) might be helpful for their safe use outside of a PICU setting. An implication for practice from this study was the use of HFO therapy on the general unit being associated with a decrease in frequency of PICU transfers, initial PICU admissions, and a decrease in total hospital LOS, yet no changes occurred in length of supportive oxygen therapy, length of HFO therapy, or PICU LOS.

Conclusion

The introduction of a process change for the use of HFO therapy on the general pediatric unit in a large, suburban, Midwestern hospital was associated with a 54.5% decrease in PICU transfers, a 27% decrease in the frequency of initial PICU admissions, and a decrease in total hospital LOS by 15 hours. However, there were no changes in length of supportive oxygen therapy, length of HFO therapy, or PICU LOS. Based upon this study, the application of HFO therapy for a bronchiolitis illness on a general pediatric unit did not negatively impact patient care. Considerations for HFO therapy use should be made as bronchiolitis remains responsible for a considerable amount of pediatric inpatient hospitalizations, is associated with an increased risk of respiratory distress, and may require additional hospital resources.

References

Beggs, S., Wong, Z., Kaul, S., Odgen, K., & Walter, J. (2014). High-flow nasal cannula therapy for infants with bronchiolitis. *Cochrane Database of Systematic Reviews.* doi: https://doi.org/10.1002/14651858.CD009609.pub2

Collins, C., Chan, T., Roberts, J., Haaland, W., & Wright, D. (2017). High-flow nasal cannula in bronchiolitis: Modeling the economic effects of a ward-based protocol. *Hospital Pediatrics, 7*(8), 451-459. doi: https://hosppeds.aappublications.org/content/7/8/451

Doucette, A., Jiang, X., Fryzek, J., Coalson, J., McLaurin, K., & Ambrose, C. (2016). Trends in respiratory syncytial virus and bronchiolitis hospitalization rates in high-risk infants in a United States nationally representative database, 1997-2012. *Plos One*. doi: https://doi.org/10.1371/journal.pone.0152208

Franklin, D., Babl, F., Schlapbach, L., Oakley, E., Craig, S., Neutze, J., … & Schibler, A. (2018). A randomized trial of high-flow oxygen therapy in infants with bronchiolitis. *The New England Journal of Medicine, 378,* 1121-1131. doi: 10.1056/NEJMoa1714855

Heikkila, P., Forma, L., Korppi, M. (2014). Hospitalization costs for infant bronchiolitis are up to 20 times higher if intensive care is needed. *Acta Paediatrica, 104*, 269-273. doi: https://doi.org/10.1111/apa.12881

Kepreotes, E., Whitehead, B., Attia, J., Oldmeadow, C., Collison, A., Searles, A., … & Mattes, J. (2017). High-flow warm humidified oxygen versus standard low-flow nasal cannula oxygen for moderate bronchiolitis (HFWHO RCT): An open, phase

4, randomized controlled trial. *Lancet, 369,* 930-939. doi: http://doi.org/10.1016/S0140-6736(17)30061-2

Mayfield, S., Bogossian, F., O'Malley, L., & Schibler, A. (2014). High-flow nasal cannula oxygen therapy for infants with bronchiolitis: A pilot study. *Journal of Paediatrics and Child Health, 50*(5), 373-378. Doi: 10.1111/jpc.12509

Moore, B., Freeman, W., & Jiang, J. (2019). *Statistical brief #250: Cost of pediatric hospital stays, 2016*. Retrieved August 14, 2019 from the Agency for Healthcare Research and Quality (AHRQ) website: https://www.hcup-us.ahrq.gov/reports/statbriefs/sb250-Pediatric-Stays-Costs-2016.pdf

Ralston, S., Lieberthal, A., Meissner, C., Alverson, B., Baley, J., Gadomski, A., … & Hernandez-Cancio, S. (2014). Clinical practice guidelines: The diagnosis, management, and prevention of bronchiolitis. *Pediatrics, 134*(5), e1474-e1502. doi: 10.1542/peds.2015-2862

Riese, J., Fierce, J., Riese, A., & Alverson, B. (2015). Effect of a hospital-wide high-flow nasal cannula protocol on clinical outcomes and resource utilization of bronchiolitis patients admitted to the PICU. *Hospital Pediatrics, 5*(12), 613-618. doi: 10.1542/hpeds.2014-0220

Riese, J., Porter, T., Fierce, J., Riese, A., Richardson, T., & Alverson, K. (2017). Clinical outcomes of bronchiolitis after implementation of a general ward high-flow nasal cannula guideline. *Hospital Pediatrics, 7*(4), 197-203. doi: 10.1542/hpeds.2016-0195

Schlapbach, L., Straney, L., Gelbart, B., Alexander, J., Franklin, D., Beca, J., … & Schibler, A. (2017). Burden of disease and change in practice in critically ill

infants with bronchiolitis. *European Respiratory Journal*, *49*(6). doi: 10.1183/13993003.01648-2016

The W. Edwards Deming Institute. (n.d.). *PDSA cycle.* Retrieved October 9, 2019 from: https://deming.org/explore/p-ds-a

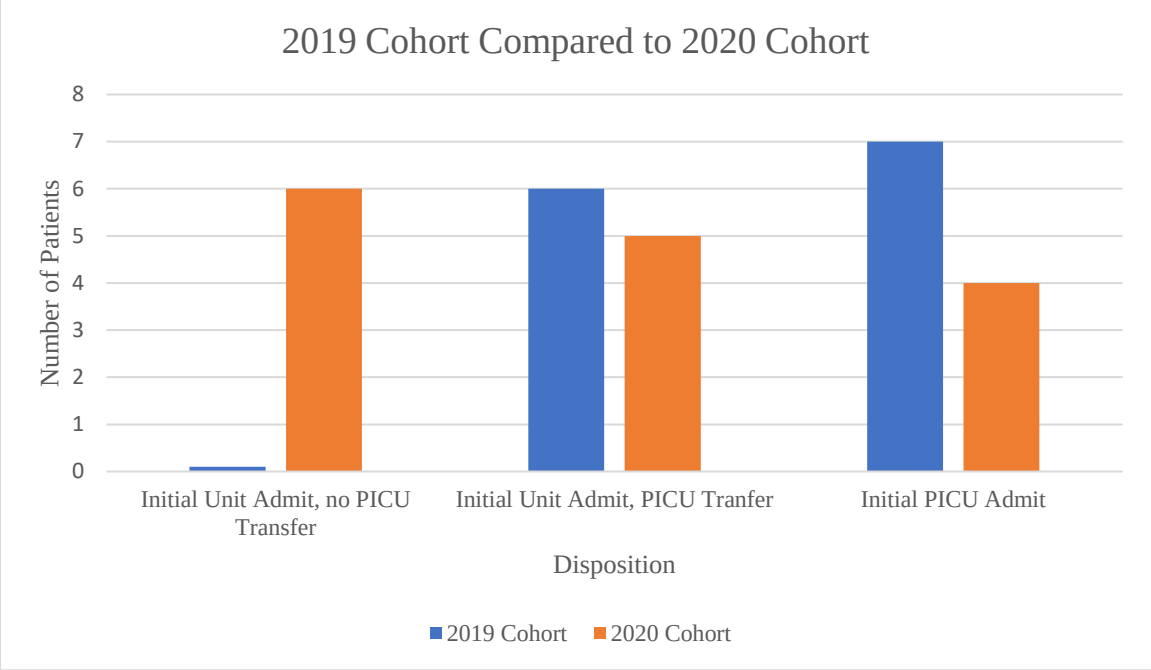
Appendix A

Table 1. *2019 & 2020 Cohort Demographics*

	2019 Cohort	2020 Cohort
Gender – no (%)		
Male	10 (77%)	5 (33.3%)
Female	3 (23%)	10 (66.7%)
Race – no (%)		
Caucasian	12 (92.3%)	10 (66.7%)
African-American	1 (7.7%)	3 (20%)
Indian		2 (13.3%)
Age – no (%)		
Mean weeks (*SD*)	9.8 (*5.6*)	24.9 (*18.2)*
2-weeks	1 (7.7%)	
3-weeks		1 (6.6%)
4-weeks	1 (7.7%)	1 (6.6)
5-weeks	2 (15.4%)	1 (6.6%)
6-weeks		1 (6.6%)
7-weeks	1 (7.7%)	1 (6.6%)
8-weeks	3 (23%)	1 (6.6%)
12-weeks	1 (7.7%)	
16-weeks	3 (23%)	1 (6.6%)
20-weeks	1 (7.5%)	
28-weeks		1 (6.6%)
32-weeks		1 (6.6%)
40-weeks		1 (6.6%)
44-weeks		4 (26.6%)
48-weeks		1 (6.6%)
Initial Unit Admissions		
	6 (46%)	11 (73%)
Initial PICU Admissions		
	7 (54%)	4 (27%)
PICU Transfers		
	6/6 (100%)	5/11 (45.5%)

Appendix B

Figure 1. 2019 Cohort Compared to 2020 Cohort

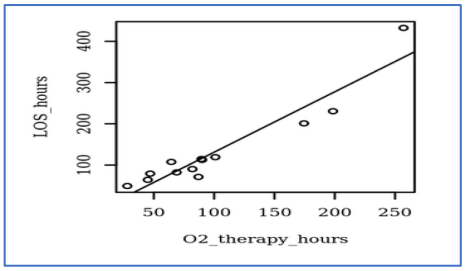


Note. A Fischer's Exact Test was used to examine if general unit admissions and PICU transfers were independent of each other in the 2020 cohort. The initial general unit admission rate in the 2020 cohort was 11 but five were transferred to the PICU (p = .231). Hence, in 2020, a general unit admission was not likely to result in a transfer to the PICU. A nonparametric test was unable to be performed on the 2019 cohort data due to the perfect collinearity of the data.

Appendix C

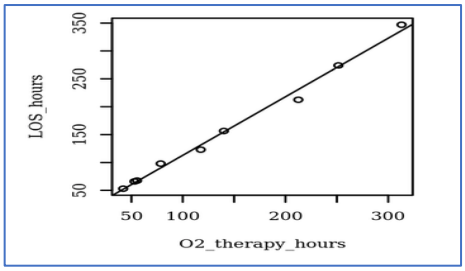
Figures 2 – 5. Supportive Oxygen Therapy compared with LOS and length of HFO therapy.

Figure 2. 2019 Cohort – LOS compared to Length of Oxygen Therapy



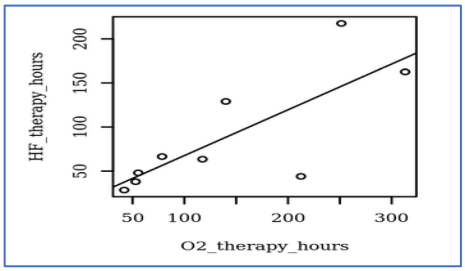
Note. $r_p = 0.95$, $p < .001$

Figure 3. 2020 Cohort – LOS compared to Length of Oxygen Therapy



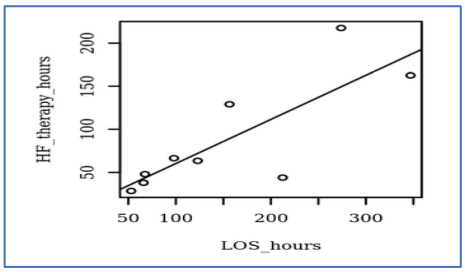
Note. $r_p = 1.00$, $p < .001$

Figure 4. 2020 Cohort – Length of Supportive Oxygen Therapy compared to Length of HFO Therapy



Note. $r_p = 0.77$, $p = 0.15$

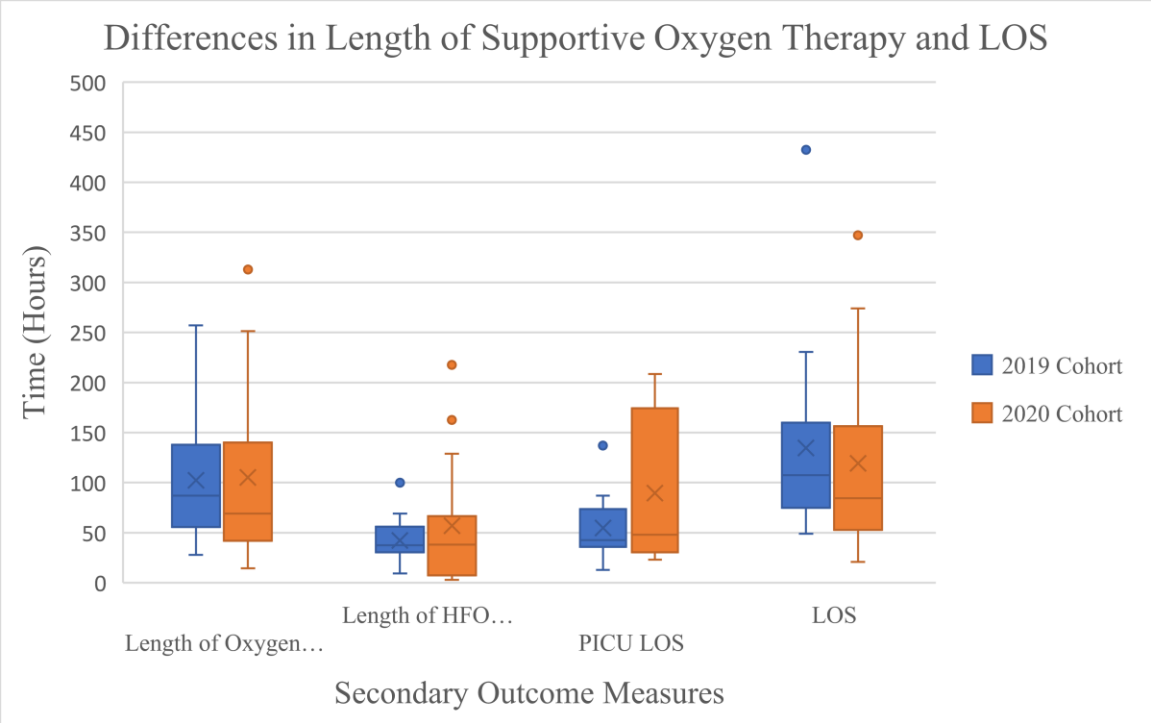
Figure 5. 2020 Cohort – LOS compared to Length of HFO Therapy



Note. $r_p = 0.80$, $p = 0.10$

Appendix D

Figure 6. Differences in Length of Supportive Oxygen Therapy and LOS



Note: Length of oxygen therapy: $p = .933$

Length of HFO therapy: $p = .448$

PICU LOS: $p = .154$

LOS: $p = .683$