Pediatric Quality and Safety

Reducing Unnecessary High Flow Nasal Cannula Oxygen Usage in Mild to Moderate Bronchiolitis

--Manuscript Draft--

Manuscript Number:	
Full Title:	Reducing Unnecessary High Flow Nasal Cannula Oxygen Usage in Mild to Moderate Bronchiolitis
Article Type:	Individual QI Projects from Single Institutions
Keywords:	bronchiolitis; high flow nasal cannula; low flow nasal cannula
Corresponding Author:	Shaila Siraj, M.D. Johns Hopkins All Children's Hospital St Petersburg, FL UNITED STATES
Corresponding Author's Institution:	Johns Hopkins All Children's Hospital
First Author:	Shaila Siraj, M.D.
Order of Authors:	Shaila Siraj, M.D.
	Brandy Compton, M.D.
	Brittney Russell, D.O.
	Shawn Ralston, M.D.
Manuscript Region of Origin:	UNITED STATES
Abstract:	Background: Heated high flow nasal cannula (HHFNC) therapy for bronchiolitis has become increasingly popular without evidence that this costly therapy impacts patient outcomes. Lack of criteria for appropriate may lead to overutilization, resulting in increased costs without patient benefit. Objective: Our primary aim was to decrease use of HHFNC in mild to moderate bronchiolitis over one bronchiolitis season. Design/Methods: Patients with Bronchiolitis < 2 years of age admitted to 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 LFNC trials prior to HHFNC initiation. We compared pre-intervention HHFNC utilization (December 2018 - April 2019) with post-intervention HFNC utilization (December 2019 to March 2020). Results: One hundred ninety patients met inclusion criteria, 98 of them in the pre-intervention cohort and 92 in the post-intervention cohort. Overall, the median age was 9.1 months and 65% of patients were male. Our HHFNC utilization rate decreased from 62% (61/98) to 43% (40/92) in the post-intervention period. Our SPC analysis suggested special cause variation based on 8 points below the pre-intervention mean. Incremental cost per case declined from $84.15 pre-intervention to $59.20 post-intervention. Conclusions: Our QI intervention implementing a specified LFNC trial prior to 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.
Suggested Reviewers:	Huay-ying Lo hxlo@texaschildrens.org
	Courtney Charvat courtney.t.charvat@emory.org
	Kristin Shadman kshadman@wisc.edu
Corresponding Author E-Mail:	ssiraj2@jh.edu

Reducing Unnecessary High Flow Nasal Cannula Oxygen Usage in Mild to Moderate Bronchiolitis

Shaila Siraj, MD[1,2], Brandy Compton MD[2], Brittney Russell DO[2], Shawn Ralston MD[1].

Affiliations: [1]Department of Pediatrics, Johns Hopkins University School of Medicine, Baltimore, MD, [2]Department of Pediatrics, University of South Florida College of Medicine, Tampa, FL

Address correspondence to: Shaila Siraj, MD; Clinical Instructor, Johns Hopkins University School of Medicine, Johns Hopkins All Children's Hospital, 501 Sixth Avenue South, Dept 7845, Saint Petersburg, FL 33701, Telephone 727-767-2481, Fax 727-767-8612, Email: ssiraj2@jh.edu

Funding Source: No funding was secured for this study.

Financial Disclosure: All authors have no financial relationships to disclose.

Conflicts of Interest: All authors have no conflicts of interest to disclose.

Contributor Statements:

Dr. Siraj conceptualized and designed the study, drafted the research protocol, participated in manuscript drafting, and approved the final manuscript as submitted.

Dr. Compton assisted with data collection and multidisciplinary hospital-wide education.

Dr. Russell assisted with data collection and multidisciplinary hospital-wide education.

Dr. Ralston conceptualized and designed the study, drafted the research protocol, participated in data extraction / quality review, performed statistical analyses, assisted with manuscript drafting, provided scientific mentorship, and approved the final manuscript as submitted.

Abbreviations: HHFNC- Heated High Flow Nasal Cannula, LFNC- Low Flow Nasal Cannula; LOS – length of stay; PICU – pediatric intensive care unit

Keywords: bronchiolitis; high flow nasal cannula; low flow nasal cannula

ABSTRACT

Background: Heated high flow nasal cannula (HHFNC) therapy for bronchiolitis has become increasingly popular without evidence that this costly therapy impacts patient outcomes. Lack of criteria for appropriate may lead to overutilization, resulting in increased costs without patient benefit.

Objective: Our primary aim was to decrease use of HHFNC in mild to moderate bronchiolitis over one bronchiolitis season.

Design/Methods: Patients with Bronchiolitis < 2 years of age admitted to 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 LFNC trials prior to HHFNC initiation. We compared pre-intervention HHFNC utilization (December 2018 - April 2019) with post-intervention HFNC utilization (December 2019 to March 2020).

Results: One hundred ninety patients met inclusion criteria, 98 of them in the pre-intervention cohort and 92 in the post-intervention cohort. Overall, the median age was 9.1 months and 65% of patients were male. Our HHFNC utilization rate decreased from 62% (61/98) to 43% (40/92) in the post-intervention period. Our SPC analysis suggested special cause variation based on 8 points below the pre-intervention mean. Incremental cost per case declined from $84.15 pre-intervention to $59.20 post-intervention.

Conclusions: Our QI intervention implementing a specified LFNC trial prior to 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.

INTRODUCTION

Bronchiolitis is a leading cause of inpatient hospitalizations among children less than two years of age and is associated with estimated direct annual costs of over US $700 million.[1] As such, a multitude of efforts have emerged to address quality of care for bronchiolitis, stressing the importance of adhering to evidence-based guidelines for the diagnosis and management of patients diagnosed with acute bronchiolitis.[2] Application of this framework has reduced the usage of some non-evidence-based interventions such as chest radiography, corticosteroids, and bronchodilators.[3,4]

Heated high flow nasal cannula (HHFNC) oxygen has gained popularity in the care of patients with bronchiolitis but was not addressed in the latest guidelines. Despite promising initial observational evidence on this intervention,[5,6] the two randomized trials in hospitalized patients with moderate bronchiolitis provide clear evidence that early use of HHFNC does not impact outcomes.[7,8]. Kepreotes et al randomized 202 children with moderate bronchiolitis to either HHFNC or standard low flow oxygen therapy upon admission.[7] There were no differences in duration of oxygen therapy, or in the overall length of stay (LOS) or pediatric intensive care unit (PICU) transfer rate. Franklin et al performed a similar randomized controlled trial including 1472 patients, also finding no differences in duration of oxygen therapy, length of hospital stay or intubation rates.[8] These findings have been echoed in recent larger observational studies in the US and Canada, demonstrating no beneficial outcome effect in hospitals adopting wider use of HHFNC.[9,10] Thus, the question of overutilization of this therapy has been raised.[11,12]

Based on the most recent literature, we began to perceive that the rate of HHFNC usage in patients admitted to our children's hospital's general inpatient units with bronchiolitis as inordinately high. Thus, our specific aim in this quality improvement study was to decrease use of HHFNC in mild to moderate bronchiolitis in patients admitted to our ward over one bronchiolitis 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. We admit approximately ~300 patients with acute viral bronchiolitis annually and had an established institutional bronchiolitis pathway in place for 2 years at the time of project initiation. Our pathway includes a respiratory distress scoring system adapted from published work.[13] The scoring tool served as a guide to categorize patients as mild, moderate and severe bronchiolitis with interventions suggested by disease severity category. Patients admitted to the general pediatrics floor with bronchiolitis are managed by the pediatric hospital medicine

group as well as one of two different residency programs rotating in our hospital. Our pathway allows for use of HHFNC on the general pediatrics wards in previously healthy children with acute viral bronchiolitis at flow rates up to 12 liters and FiO2 up to 50%, but criteria for initiation were non-specific and there was no requirement that a patient be hypoxic prior to initiation of HHFNC.

Population

We included patients aged 1 month to 24 months admitted to the hospital with mild to moderate acute viral bronchiolitis from Dec 2019 through March 2020. Every 2 weeks, we manually chart reviewed all patients receiving ICD-10 billing codes for acute viral bronchiolitis (J21.0, J21.1, J21.8, J21.9) and/or acute respiratory failure (J96.00) to find patients that were initially admitted to the general pediatric floor and to ensure that they met clinical history and physical examination consistent with bronchiolitis, 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 admitted initially to the general pediatrics floor from Dec 2018-April 2019 at our institution.

Intervention

We utilized the model for improvement framework for our quality improvement initiative.[14] 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, beliefs about the therapy. Key drivers of overuse of HHFNC we chose for focus included (1) lack of available guidance on initiation criteria for use of HHFNC (2) knowledge gap on current literature on efficacy of HHFNC and (3) concerns surrounding patient experience.

We then attempted to standardize formal initiation criteria but struggled to reach consensus without existing published guidance on the topic. We ultimately proposed a single change to the existing emergency department and inpatient bronchiolitis algorithms for which we could easily achieve consensus. We added a trial of LFNC for at least 30 min with subsequent reassessment prior to the initiation of HHFNC. Our updated pathways are presented as Supplemental Figure 1 (ED) and Supplemental Figure 2 (Inpatient) with the specific change we made 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 the nursing and respiratory therapy leadership and attended

their group meetings to discuss the changes. Education for resident physicians was performed at academic lectures and orientation to the wards service.

Study of the Intervention

We provided feedback on the primary and secondary outcomes to stakeholders in two-weekly intervals using simple run charts. Throughout the project, team leaders discussed cases that did not adhere to the new algorithm to encourage feedback and familiarity with the change. We chose to track a process measure, protocol compliance with the LFNC trial, as well as our primary outcome of HHFNC usage with the hypothesis that protocol compliance should track along with any change in the primary outcome if there was a cause and effect relationship between the two.

Measures

The primary outcome in this study was rate of HHFNC use in patients admitted to the general ward with viral bronchiolitis between December 2019-March 2020, defined as the number of patients placed on any amount of HHFNC over the total number of patients admitted to the general pediatrics floor. Our secondary outcome was protocol compliance, defined as the number of patients who received the recommended LFNC trial prior to HHFNC initiation over the total number of patients on HHFNC. Our balancing measure was rate of unplanned transfers to the PICU within 24 hours of admission to assess for the possibility of unintentional harm due to the protocol change. Other secondary outcomes were LOS and estimated direct costs of HHFNC usage. Direct costs were calculated using only the cost of the HHFNC setup used at our institution, not including labor costs.

Analysis

We analyzed the data using statistical process control methods. Western Electric rules for establishing special cause were pre-specified[15]. Baseline values were calculated by using the 5 months of the preceding bronchiolitis season December 2018 – April 2019. Postintervention data are reported for 4 months from Dec 2019–Mar 2020 as the project was stopped early due to the COVID-19 pandemic which terminated the bronchiolitis season early due to school closures and social distancing measures, resulting in dramatic decline in census.

Ethics

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

RESULTS

In this study 190 patients admitted to the general pediatrics ward with bronchiolitis were included. There was a total of 98 patients in the preintervention cohort and 92 in the postintervention cohort. Patient characteristics in each cohort are presented in Table 1. Overall, the median age was 9.1 months and 65% of patients were male. Our HHFNC utilization rate decreased from 62% (61/98) to 43% (40/92) in the post-intervention period. Our SPC analysis suggested special cause variation based on 8 points below the pre-intervention mean (Figure 1). Of the patients placed on HHFNC, 39% (24/61) were initially trialed on standard low flow nasal cannula (LFNC) prior to the initiation of HHFNC in the pre-intervention period compared to 73% (29/40) in the post-intervention period (Figure 2). Our SPC analysis suggested special cause based on 2 out 3 consecutive points above 2 sigma in the post-intervention period.

Our system direct cost for the HHFNC setup alone were between $98 and $198 depending on flow rate. Total direct costs of the HHFNC cartridges were $8878 preseason and $5720 postintervention. Incremental cost per case declined from $84.55 pre-intervention to $58.60 post-intervention (Figure 3), though special cause was likely due to the COVID-19 pandemic.

Overall mean length of stay in our study population did not change, with an average of 2.7 days pre-intervention and 2.6 days post-intervention. Our balancing measure appeared unchanged, with 6 (6.1%) unplanned PICU transfers in the bronchiolitis population in the pre-intervention period and 7 (7.6%) in the post-intervention period. Time between transfers demonstrated a similar pattern pre and post intervention (Figure 4), with 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 43% after a relatively simple intervention. This change to our pathway guided providers to attempt a LFNC trial prior to the initiation of HHFNC for patients with mild to moderate disease severity which we hypothesized would be sufficient intervention for many patients. We tracked both compliance with this recommendation as well as overall HHFNC use in order to more clearly establish that this specific change resulted in the desired outcome and found that protocol compliance indeed tracked with decreased HHFNC usage. Furthermore, we noted that noncompliance with the new protocol (occurring in 11 patients) occurred primarily in patients under the care of per diem providers (8 of 11) who would not have received our interventions or been as aware of our pathways.

Unfortunately, we had to prematurely terminate our project at the end of March 2020 due to the COVID-19 pandemic which dramatically decreased our hospitalization rate and likely impacted our results. Our

data point for the last two weeks of March indicating zero HHFNC usage is an outlier and was certainly impacted by the pandemic in terms of likelihood that a patient would receive HHFNC given concern that it may be an aerosolizing procedure. While all of our prior datapoints had been below the pre-intervention mean up until that time, we believe the zero use that occurred during that timeframe was due to external events and not directly linked to our intervention. 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 costly therapy. In fact, the increasingly widespread use of HHFNC for other conditions including asthma and pneumonia without proven data on efficacy suggests the potential for indication creep. As noted previously, HHFNC has not been shown to improve clinical outcomes in patients with bronchiolitis and therefore indiscriminate use of this costly therapy has been questioned. A recent analysis evaluating the cost of providing high flow therapy as first line therapy compared to rescue therapy after failure of standard oxygen revealed that the mean cost of bronchiolitis treatment (including intervention costs and costs associated with LOS) was AU$420 higher in the early HHFNC group compared to the rescue HHFNC group[16]. We did not attempt to calculate labor costs as that may overestimate cost savings unless total number of employees can truly be reduced due to a single project, thus our conservative estimate of cost savings at $3158 is modest. Nevertheless, we would suggest that a parsimonious approach to the use of HHFNC will save a significant amount of money for a health system over time without significant risk.

Our study has limitations, the most important being that we had to terminate prematurely due to a dramatic decline in volume of hospitalizations due to the COVID-19 pandemic. It is possible that HHFNC use will revert to the mean with decreased scrutiny, and that the proposed association of our intervention with the outcome of interest was due to the Hawthorne effect. Furthermore, our study only includes one season of bronchiolitis data and therefore conclusions surrounding long term implications are limited. We did not collect data on oxygen saturation values at the time of initiation of LFNC or HHFNC since our institutional practice was to focus on respiratory effort and not a prespecified 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, although such a substitution would not negate the cost savings noted in our project.

CONCLUSIONS

HHFNC has not been proven to alter patient-centered outcomes in mild to moderate acute viral bronchiolitis. Our QI intervention implementing a trial of standard LFNC prior to the initiation of

HHFNC shows promise in reducing the overuse of this therapy. Future studies should focus on clear initiation and discontinuation criteria for HHFNC use in bronchiolitis.

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Figure 1

Figure 1. Proportion of Bronchiolitis Patients Receiving High Flow Nasal Cannula Over Total Number of Bronchiolitis Patients Admitted to the Hospital Medicine Service (p Chart)

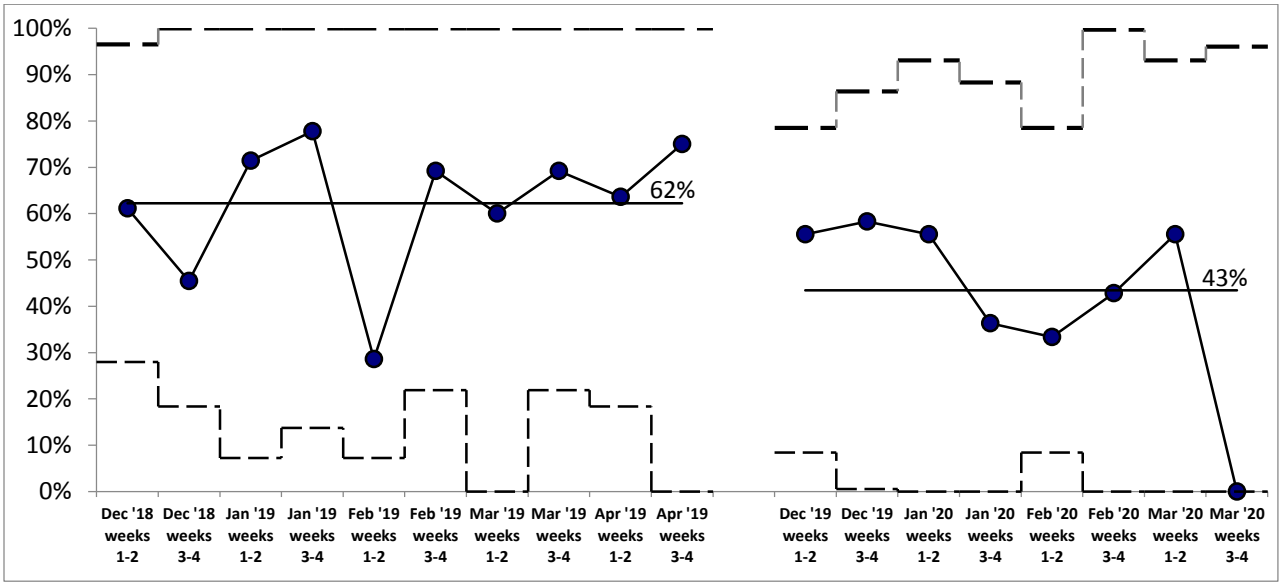


Figure 2

Figure 2. Proportion of Bronchiolitis Patients Receiving a Trial of Low Flow Oxygen Prior to High Flow Nasal Cannula Initiation (p Chart)

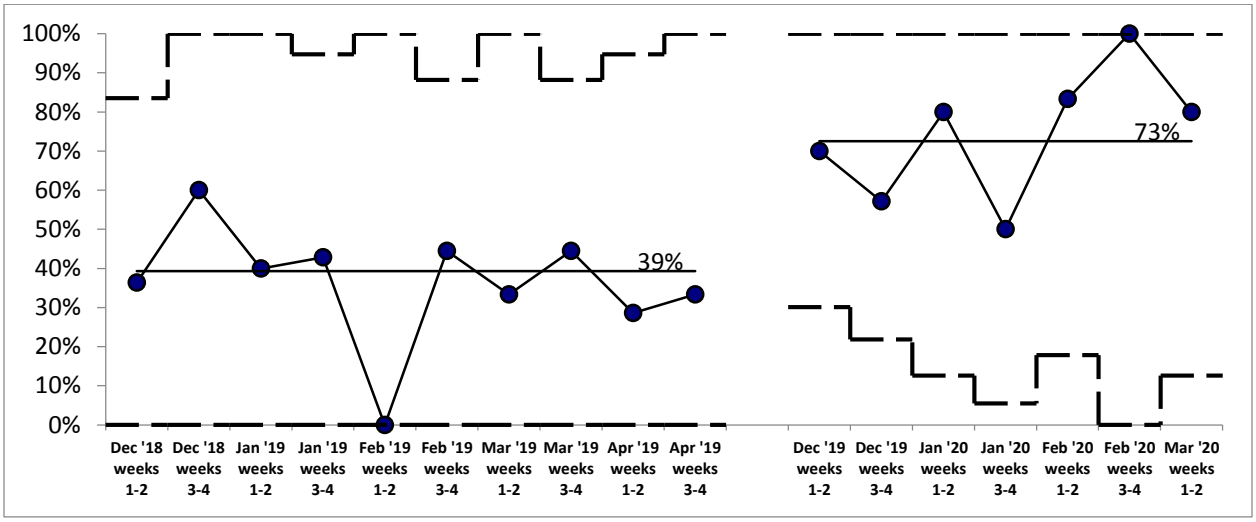


Figure 3

Figure 3. Incremental Cost per Case Attributed to the Use of High Flow Nasal Cannula (X-chart)

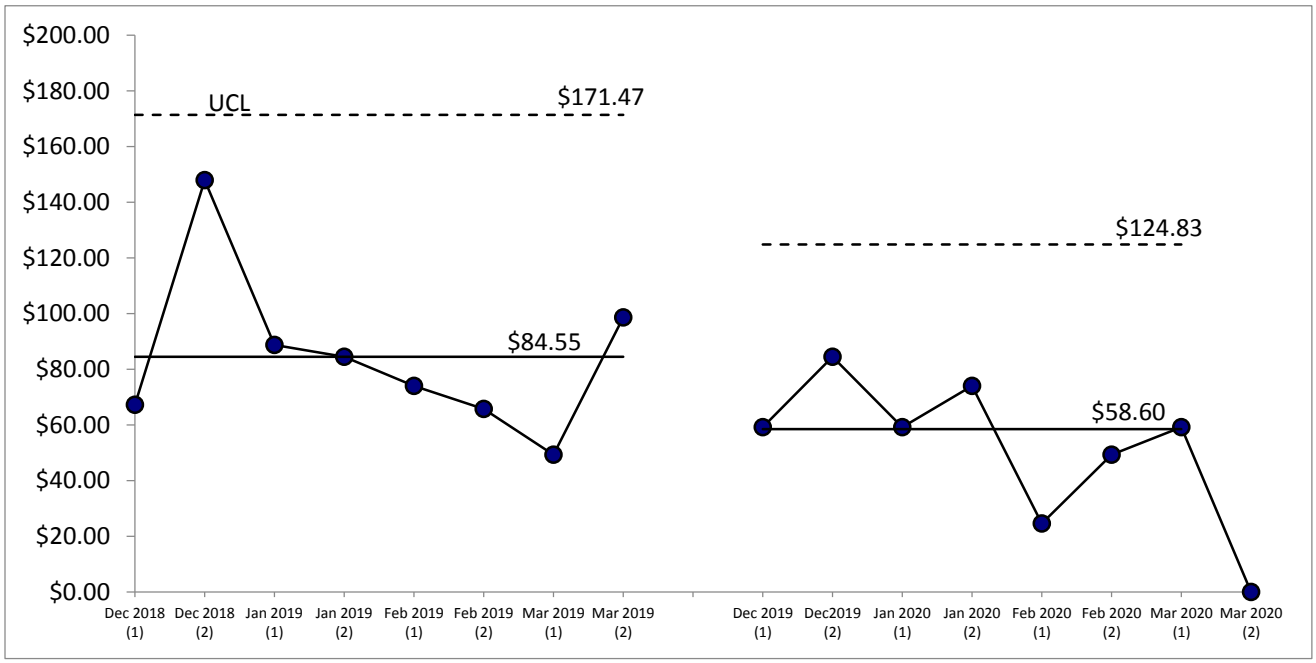
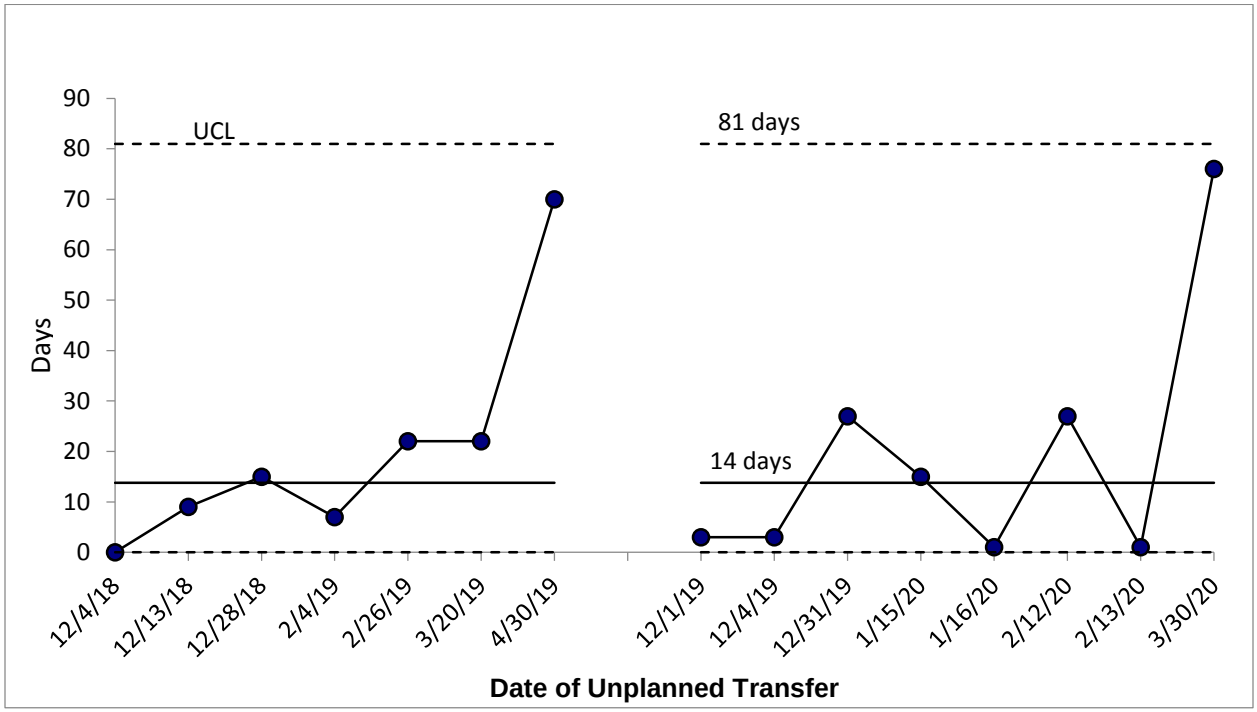


Figure 4

Figure 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 pre-intervention seasonal data. The graph on the right represents data during the intervention season.



Table

Table 1: Demographics for Study Population

Patient Characteristics	All Patients (n=190)	Preintervention (n=98)	Postintervention (n=92)
Mean age, months	9.1 ± 7.1	9.9 ± 7.9	8.3 ± 6.2
Male	64.7% (123/190)	61.2% (60/98)	68.4% (63/92)
Length of Stay, Days	2.6 ± 2.1	2.7 ± 2.5	2.6 ± 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	1.9 ± 0.99	1.8 ± 0.67	1.9 ± 0.88

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