RESEARCH ARTICLE

High-Flow Nasal Cannula in Bronchiolitis: Modeling the Economic Effects of a Ward-Based Protocol

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ABSTRACT

OBJECTIVES: High-flow nasal cannula (HFNC) use has increased in patients with bronchiolitis, with the majority of use restricted to the ICU. Broadening HFNC to the wards may have substantial economic implications. This study compares the cost of a standardized clinical pathway that permits HFNC use in the wards for patients with bronchiolitis with an ICU-only HFNC care model.

METHODS: We constructed a decision analytic model to simulate 2 options for treating bronchiolitic patients: one in which HFNC is used in the wards (ward HFNC) and one in which HFNC is restricted to the ICU (ICU HFNC). The model inputs were based on patients admitted with bronchiolitis without major comorbidities between 2010 and 2015. 1432 patients were included for analysis. We simulated 10 000 patients for 5000 trials to assess parameter variability and sampling uncertainty, respectively. The primary outcome was average admission cost per patient. The secondary outcome was average length of stay (LOS) per patient.

RESULTS: In the model, the average admission cost per patient for the ward HFNC group was $7020 (95% confidence interval [CI] $6840–$7194) compared with $7626 (95% CI $7427–$7839) in the ICU HFNC group, with a net difference of $606 (95% CI $408–$795). The average LOS for the ward HFNC group was 2.29 days (95% CI 2.24–2.33) compared with 2.61 days (95% CI 2.56–2.66) in the ICU HFNC group, with a net difference of 0.32 days (95% CI 0.27–0.37).

CONCLUSIONS: Using HFNC in the ward for bronchiolitis may be cost-effective and may decrease LOS compared with ICU-only HFNC.

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Bronchiolitis is one of the most common illnesses affecting young children, accounting for 16% to 18% of hospital admissions in the first 2 years of life.[1,2] The authors of the most recent national report estimate $1 730 000 000 in hospital charges for pediatric patients with bronchiolitis in 2009.[2] Although many therapies for bronchiolitis have been studied, no treatment has been shown to shorten the duration of illness or decrease hospitalization rates.[3] Therefore, new bronchiolitis management strategies need to be systematically and critically evaluated to ensure that treatments are not increasing cost without improving health outcomes.

High-flow nasal cannula (HFNC) is frequently used in bronchiolitis patients to provide humidified oxygen and end-expiratory pressure, which may decrease work of breathing.[4–7] HFNC use is commonly restricted to the ICU, but some hospital practitioners have demonstrated safe use of HFNC on infants with bronchiolitis in the general ward.[8–10] If HFNC can be safely used in general pediatric wards, this may result in cost savings because of lower ICU use, especially if HFNC can decrease intubation rates as some researchers suggest.[11–13] However, if HFNC use increases substantially in less ill children (and without significant improvement of clinical outcomes), there is a risk that the increased cost associated with overusing HFNC (which costs ~$328 per day in 2014 US dollars at our institution) will surpass the cost savings of avoiding ICU admissions. This would lead to an increased cost to care for each seasonal cohort of patients with bronchiolitis. Additionally, trying to evaluate the effect of HFNC as it relates to improvement in clinical outcomes is challenging; available studies use historical controls and have difficulty accounting for seasonal variability, changes in hospital culture, and practice variations that may influence health and utilization outcomes.[11–13] By using a decision analytic model, cost and length of stay (LOS) can be simulated, while accounting for the previously mentioned concurrent changes, to assess the cost consequences of using HFNC in the wards. The objective of this study was to develop a decision analytic model informed by hospital administrative data to assess the cost effects of a ward-based HFNC clinical pathway compared with ICU-restricted HFNC use for patients with bronchiolitis.

METHODS

A clinical pathway to standardize use of HFNC in the pediatric ward for patients with bronchiolitis was developed at Seattle Children's Hospital a freestanding tertiary care children's hospital that serves the Northwest region of the United States (see Supplemental Fig 3 for the pathway). The pathway was intended to guide providers on how to use HFNC safely; its authors outlined which patients were optimal candidates (those without pre-existing medical conditions) and provided an algorithm of age-based flow rates. Clinical re-evaluation was required for patients trialed on HFNC and failure to improve was an indication for ICU admission. If admitted to the ward, nurses standardly assessed patients with bronchiolitis, depending on level of respiratory support (see Supplemental Fig 4 for details on the acute care model). We obtained data on all patients <2 years old admitted to the hospital with a diagnosis of bronchiolitis and without major comorbidities from October 2010 to August 2015 (see Supplemental Tables 4 and 5 for *International Classification of Diseases, Ninth Revision* [ICD-9] codes). The ICD-9 codes used to define bronchiolitis (including viral pneumonia) were developed by a clinical standard work group at our institution, and our institution has used this definition of bronchiolitis since 2009. We divided the cohort into 2 groups: a group that predated the initiation of the pathway (prepathway cohort, October 6, 2010 through December 9, 2013) and a group treated after implementation of the pathway (postpathway cohort, December 10, 2013 through August 18, 2015). For each hospital day, we determined how each patient escalated or de-escalated on their respiratory support and combined this information with their location in the hospital (ICU or ward). The determination of respiratory support and location were informed by billing data and electronic medical records via an administrative data set. Data that deviated from expected ranges were validated by consulting the electronic medical record. Daily and total admission cost data for each patient were collected from administrative records and were used to inform the model inputs. This study was approved by the Seattle Children's Hospital Institutional Review Board.

Decision Analytic Model

We developed a Markov decision analysis microsimulation model in TreeAge (TreeAge Pro Healthcare 2016; TreeAge Software Inc, Williamstown, MA) to model and compare the costs and LOS of healthy bronchiolitis patients treated with the current practice (HFNC allowed in the ward, ward HFNC branch) and a hypothetical counterfactual practice (HFNC use only in the ICU, ICU HFNC branch). Markov modeling is a form of decision analysis that simulates patient transitions between distinct health states over time and has been applied to various health care situations.[14] We modeled cases over 24 days, the longest LOS in both cohorts. In the ward HFNC branch, we assigned patients to 1 of 7 states for every day of the hospitalization on the basis of their location and highest level of respiratory support: (1) ward, no respiratory support (meaning simple nasal cannula or room air), (2) ward on HFNC, (3) ICU, no respiratory support, (4) ICU HFNC, (5) ICU noninvasive positive-pressure ventilation (NIPPV), which is continuous positive airway pressure or bilevel positive pressure, (6) ICU invasive ventilation, or (7) discharged. In the ICU HFNC branch, there were 6 states, the same states as the HFNC branch but with omission of the ward on HFNC state. The Markov model allowed for transitions between states every 24 hours, which was chosen because bed charges are assigned at midnight on each day of admission. Of note, patients admitted on room air or on nasal cannula were grouped into the same cohort because nasal cannula support does not require additional respiratory therapy or a higher level of nursing care at our institution. An example of a patient admitted to the ward with no respiratory support with the available

transitions (depending on whether HFNC is allowed in the ward) is shown in the simplified model schematic in Fig 1. The complete decision tree used in the model can be found in the Supplement (Supplemental Fig 5). Readmission was not modeled because readmission rates were low (2.9%), and there were no differences in readmission rates between the pre- and postpathway cohorts.

Model Input Data

Probabilities (Table 1) for the admission state (location and level of respiratory support) for the non-ICU branches of our ward HFNC branch were derived from postpathway cohort admission data, in which the frequency of admission to each state is equivalent to the initial probability for each state. All ICU branch initial probabilities, not including HFNC in the ICU,

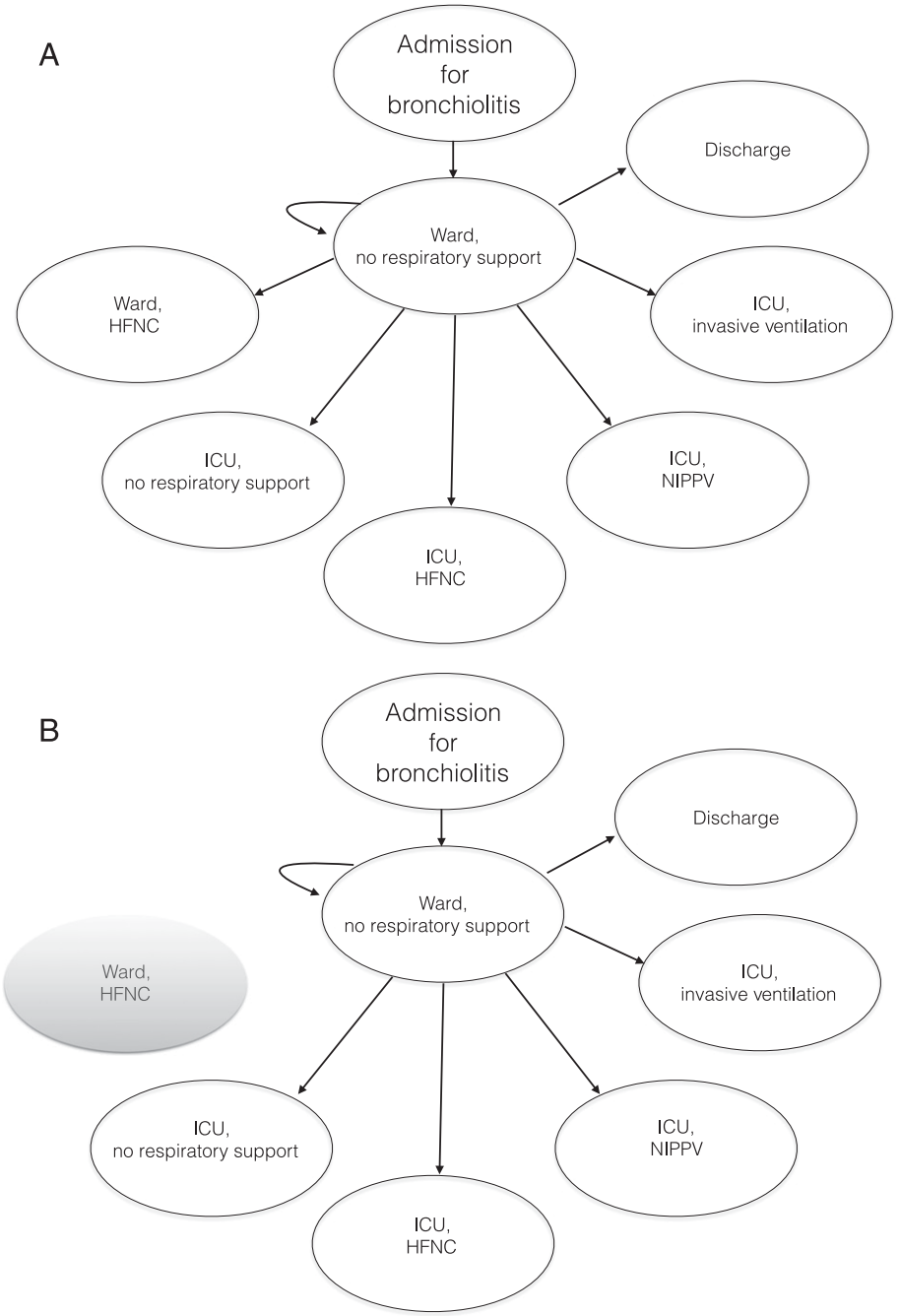

FIGURE 1 Simplified Markov diagram of a patient admitted to the ward with no respiratory support. A, An example of a patient admitted to the ward, no respiratory support branch with the available transitions for the Ward HFNC branch. B, An example of a patient admitted to the ward, no respiratory support branch with the available transitions for the ICU HFNC branch.

TABLE 1 Initial Probabilities and Transition Probabilities From Day 0 to Day 1 for Ward HFNC and ICU HFNC Branches

	Initial State and Probability	Next State	Day 0 to Day 1 Probabilities
Ward HFNC	Ward, no respiratory support 0.79180	Ward, no respiratory support	0.38498
		Ward, HFNC	0.01643
		ICU, no respiratory support	0.00000
		ICU, HFNC	0.03052
		ICU, NIPPV	0.00000
		ICU, invasive ventilation	0.00000
		Discharge	0.56808
	Ward, HFNC 0.09480	Ward, no respiratory support	0.00000
		Ward, HFNC	0.76471
		ICU, no respiratory support	0.00000
		ICU, HFNC	0.13725
		ICU, NIPPV	0.00000
		ICU, invasive ventilation	0.00000
		Discharge	0.09804
	ICU, no respiratory support 0.00800	Ward, no respiratory support	0.66667
		ICU, no respiratory support	0.33333
		ICU, HFNC	0.00000
		ICU, NIPPV	0.00000
		ICU, invasive ventilation	0.00000
		Discharge	0.00000
	ICU, HFNC 0.09325	Ward, no respiratory support	0.00000
		Ward, HFNC	0.17647
		ICU, no respiratory support	0.01961
		ICU, HFNC	0.47059
		ICU, NIPPV	0.27451
		ICU, invasive ventilation	0.01961
		Discharge	0.03922
	ICU, NIPPV 0.00765	Ward, no respiratory support	0.00000
		Ward, HFNC	0.25000
		ICU, no respiratory support	0.00000
		ICU, HFNC	0.00000
		ICU, NIPPV	0.50000
		ICU, invasive ventilation	0.25000
		Discharge	0.00000
	ICU, invasive ventilation 0.00450	Ward, no respiratory support	0.33333
		Ward, HFNC	0.00000
		ICU, no respiratory support	0.00000
		ICU, HFNC	0.33333
		ICU, NIPPV	0.00000
		ICU, invasive ventilation	0.33333
ICU HFNC	Ward, no respiratory support 0.87810	Ward, no respiratory support	0.57520
		ICU, no respiratory support	0.00115
		ICU, HFNC	0.00000
		ICU, NIPPV	0.00230
		ICU, invasive ventilation	0.00000
		Discharge	0.42135
	ICU, no respiratory support 0.00800	Ward, no respiratory support	0.50000
		ICU, no respiratory support	0.25000
		ICU, HFNC	0.12500
		ICU, NIPPV	0.12500
		ICU, invasive ventilation	0.00000
		Discharge	0.00000
	ICU, HFNC 0.10175	Ward, no respiratory support	0.00000
		ICU, no respiratory support	0.01307
		ICU, HFNC	0.63206
		ICU, NIPPV	0.27451
		ICU, invasive ventilation	0.01961
		Discharge	0.06075
	ICU, NIPPV 0.00765	Ward, no respiratory support	0.14286
		ICU, no respiratory support	0.14286
		ICU, HFNC	0.00000
		ICU, NIPPV	0.71429
		ICU, invasive ventilation	0.00000
		Discharge	0.00000

TABLE 1 Continued

Initial State and Probability	Next State	Day 0 to Day 1 Probabilities
ICU, invasive ventilation 0.00450	Ward, no respiratory support	0.33333
	ICU, no respiratory support	0.00000
	ICU, HFNC	0.00000
	ICU, NIPPV	0.00000
	ICU, invasive ventilation	0.66667

were weighted averages of the pre- and postpathway cohorts because of their similar probabilities. The prepathway cohort data at our institution were not an accurate representation of current hospital practice (with a lower threshold to transfer to ICU without differences in severity of illness scores) and could not be used as the sole source of initial probabilities for the ICU HFNC branch. To account for the institutional practice change regarding a lower threshold for the acuity of admission to the ICU, we assumed HFNC use (in the ICU) in the ICU HFNC branch would be higher than our historical data. For the ICU HFNC branch, any patient with a Modified Pediatric Early Warning Score (MPEWS) $\geq$2 who also had a blood gas test obtained was assigned to an initial location state in the ICU (see Supplemental Fig 6 for the MPEWS scoring system). In the postpathway cohort, these criteria correctly identified 81% of patients who were admitted to the ICU and 88% of patients who were admitted to the ward on HFNC. We applied this rule to our prepathway cohort data and arrived at an initial probability of ICU admission of 12.2%. From this 12.2% admitted to the ICU, non-HFNC ICU admissions (no respiratory support, NIPPV, or invasive ventilation) were subtracted. This resulted in the initial probability of admission to the ICU on HFNC as 10.2%, which is higher than our historical data (0.7%) but lower than our current HFNC-use rate on admission of 19% (ward HFNC plus ICU HFNC).

After the initial probability of being admitted to one of the available states, a patient would transition between states every 24 hours. The transitions between states in the ward HFNC branch were determined by the transitions made by the patients in our postpathway cohort. These transitions were specific to the day of admission. Because the historical cohort would not provide realistic contemporary transition probabilities for the ICU HFNC branch for patients treated with HFNC, we averaged the postpathway probabilities of HFNC in the ICU and in the ward. We averaged the probabilities of transitioning to different states on different days and then reproportioned these probabilities to account for ICU patients on invasive or noninvasive ventilation (see Table 1 for day 0 to day 1 transition probabilities and Supplemental Tables 6 and 7 for subsequent transitions). Consecutive days with similar probabilities were grouped to simplify the model.

Costs for each state were determined by using our prepathway and postpathway cohort admission hospital administrative data. Costs were obtained from our internal cost accounting system, Allscripts EPSi (Allscripts Healthcare Solutions, Chicago, IL). Specifically, industry standard cost-to-charge ratios are used to determine cost allocations with local variation in other costs, such as supplies and labor, which are adjusted for at the charge line item. Direct versus indirect and fixed versus variable costs are allocated at the charge line item level. Further details on our institution's costing methods can be found in a recent article by Leu et al.[15] Daily costs for each trial were randomly sampled with replacement from the cohort data for each trial in the simulation (Table 2). Costs were converted to 2014 US dollars using the US Consumer Price Index for medical care services.[16] The cost used for the model input captured all costs for a patient on a given day. Table 2 also shows the breakdown of cost per day per patient, including costs from laboratory, pharmacy, radiology, respiratory services, and room and board (which includes nursing care and is based solely on location and not acuity of the patient). Given the large amount of variability in daily service costs and the substantial complexity associated with modeling individual service costs, only total daily costs were included in the Markov model.

Total hospitalization costs are the sum of individual daily total costs for the entire time period that a simulated patient is admitted. LOS is based on a simulated patient's likelihood of transitioning to the "Discharged" state, which is based on the probability of being discharged on a given day and is derived from our cohort data.

Sensitivity and Uncertainty Analyses

We conducted a 1-way sensitivity analysis by varying the probability of being admitted to the ICU on HFNC. The postpathway cohort's probability of being admitted on HFNC (to either the ward or the ICU) is ~19% and the prepathway cohort's probability of being admitted on HFNC was $<$1%. We therefore conducted a sensitivity analysis of the probability of being admitted to the ICU on HFNC from 0% to 25%.

We also constructed the model with alternative cost inputs on the basis of the combined average cost per state between the prepathway cohort and the postpathway cohort (Supplemental Table 8). This was done to account for the higher threshold for ICU transfer in the prepathway cohort, which likely resulted in a higher-acuity ICU patient population and higher prepathway ICU costs. Alternatively, the postpathway cohort likely had higher costs in the ward because of the increased cost associated with HFNC use. Therefore, to test the robustness of the assumptions made about our inputs, the model was run with alternative cost inputs with a γ distribution.

TABLE 2 Mean Cost per Day per Patient

Model Branch	State	Mean Total Daily Cost per Patient[a] (SD)	Location	Mean Cost per Category per Day per Patient (SD)				
				Laboratory	Pharmacy	Radiology	Respiratory Therapy	Room and Board
Ward HFNC	Ward, no HFNC	2550.20 (884)	Ward	170.85 (354)	52.75 (68)	179 (57)	270.38 (168)	1789.89 (544)
	Ward, HFNC	2679.84 (681)						
	ICU, no HFNC	5507.04 (1785)	ICU	185.44 (263)	135.70 (154)	198.40 (139)	455.39 (251)	4612.22 (394)
	ICU, HFNC	5778.44 (1221)						
	ICU, NIPPV	5975.43 (936)						
	ICU, invasive ventilation	6375.50 (891)						
ICU HFNC	Ward, no HFNC	2266.67 (785)	Ward	257.00 (253)	66.03 (106)	201.85 (49)	200.89 (182)	1719.29 (530)
	ICU, no HFNC	5446.98 (1270)	ICU	275.16 (265)	188.70 (213)	187.78 (75)	534.27 (403)	5033.16 (513)
	ICU, HFNC	5759.66 (1378)						
	ICU, NIPPV	6108.55 (1249)						
	ICU, invasive ventilation	7085.52 (1225)						

All costs in 2014 US dollars.
[a] Model inputs.

We ran 10 000 trials in each microsimulation to capture variability in model parameters; input costs were bootstrapped from actual cohort patient costs per day of admission. We conducted a probabilistic sensitivity analysis, running the microsimulation 5000 times to capture uncertainty related to sampling bias. We used probabilistic sensitivity analyses to construct 95% confidence intervals (CIs) around cost outcomes and LOS.

RESULTS

Our inclusion and exclusion criteria captured 1462 patients from our administrative data. Of these, 30 patients received nonconventional respiratory support in the ward before implementation of the pathway or had erroneous data and were excluded. Therefore, our model inputs were based on a cohort of 1432 patients. Of these, 894 (62%) patients were admitted before implementation of the pathway and 538 (38%) were admitted thereafter. For our base case model, the average modeled cost per patient per admission for the ward HFNC group was $7020 (95% CI $6840–$7194) compared with $7626 (95% CI $7427–$7839) in the ICU HFNC group. The net difference was $606 (95% CI $408–$795).

The average modeled LOS for the ward HFNC group was 2.29 days (95% CI 2.24–2.33) compared with 2.61 days (95% CI 2.56–2.66) in the ICU HFNC group. The net difference was 0.32 days (95% CI 0.27–0.37) (Table 3).

The model was not sensitive to alternative cost specifications. When alternative cost inputs were used, results were similar, with the average cost per patient per admission for the ward HFNC group totaling $7014 (95% CI $6837–$7194) compared with $7622 (95% CI $7410–$7833) in the ICU HFNC group. The net difference was $608 (95% CI $410–$805) (Table 3).

The 1-way sensitivity analysis on our ICU HFNC assumption revealed that if all other variables were held constant, admitting 6.7% of patients to the ICU on HFNC would be cost-equivalent for the 2 pathways (Fig 2). The range of cost per patient per admission in the ICU HFNC pathway varied from $5544 if 0% of patients were admitted to the ICU on HFNC to $10 730 if 25% of patients were admitted to the ICU on HFNC.

DISCUSSION

In this study, we simulated the economic effects of restricting HFNC for bronchiolitis patients to the ICU in a hospital that recently implemented HFNC use in the general pediatrics ward. We demonstrated that a clinical pathway that supports HFNC in the general pediatrics ward may be cost-effective in our current hospital environment, with ~$600 in cost savings per patient and a 7-hour shorter LOS that is attributable to the pathway. The model also indicates that admitting patients on the ICU HFNC branch to the ICU on HFNC would need to be restricted to 6.7% to achieve cost equivalence.

In our hospital, the implementation of the HFNC bronchiolitis pathway coincided with initiation of the Recognized Illness Severity in Kids (RISK) program, in which an ICU nurse circulates the ward and identifies high-risk patients who may need to transfer to the ICU. Additionally, during the same time period, the hospital's ICU capacity increased with a resulting shift toward early transfer to the ICU and conservative critical-care management of patients who were previously managed in the ward. These changes collectively resulted in a higher rate of ward-to-ICU transfers and direct ICU admissions in both bronchiolitis and nonbronchiolitis patients.

Given the complexity of the changes that were implemented, a simulation model was considered to be an optimal tool to assess the economic effect of this clinical pathway. One strength of using a decision analytic modeling approach is the ability to overcome confounding factors such as simultaneous practice and culture change

TABLE 3 Results

	Ward HFNC	ICU HFNC	Net Difference
Average cost (95% CI)	7020 (6840–7194)	7626 (7427–7839)	606 (408–795)
Average LOS, d (95% CI)	2.29 (2.24–2.33)	2.61 (2.56–2.66)	0.32 (0.27–0.37)
Average cost, alternative cost input (95% CI)	7014 (6837–7194)	7622 (7410–7833)	608 (410–805)

All costs in 2014 US dollars.

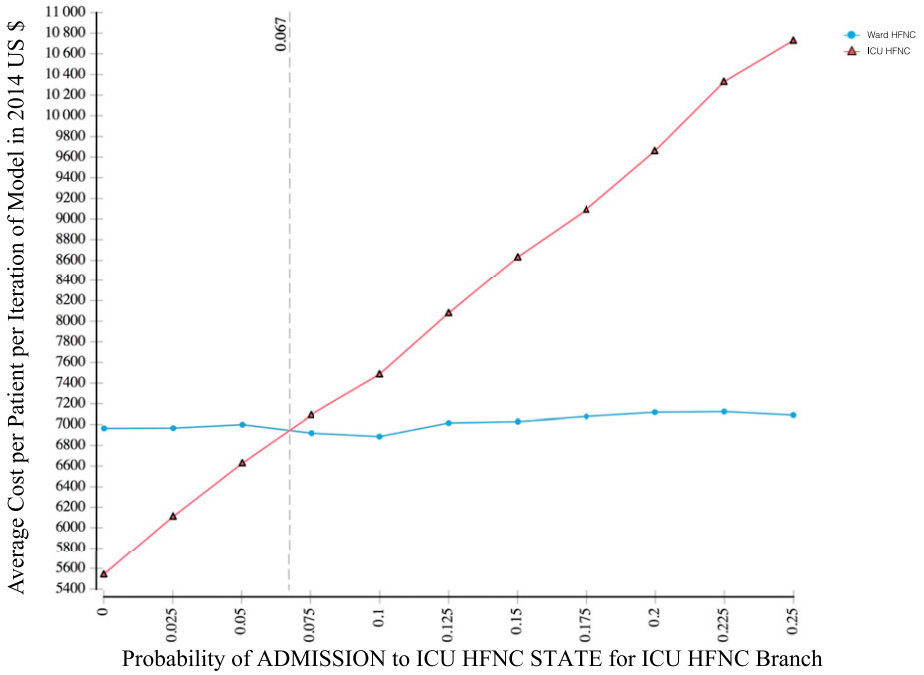

FIGURE 2 Sensitivity analysis of the ward HFNC branch.

or increased ICU capacity. By using only descriptive cost data of the cohorts before and after implementation of the ward HFNC, the ICU HFNC would be overwhelmingly dominant (lower cost because of lower rates of ICU admission and transfer and no change in outcome or LOS). Thus, a decision analytic model helps account for simultaneous changes in clinical practice that resulted in lower thresholds for ICU admission and increasing HFNC use. Interestingly, Heikkilä et al,[17] in a recent study performed in Finland, also found decision analysis to be an effective method to evaluate HFNC use in the wards for bronchiolitis. Although their methods differed in a number of ways, including using a simple decision tree in lieu of a Markov model and relying on data from the literature to inform the majority of their model inputs, the authors concluded that it would be cost-effective to admit all infants to the hospital on HFNC in their Finnish hospital system.[17]

Another strength of our study is the inclusion of the entire cohort of bronchiolitis patients admitted to the hospital. Riese et al[18] demonstrated a decrease in hospital charges and LOS when bronchiolitis patients admitted to the ICU were allowed to transfer from the ICU to the ward on HFNC. However, examinations of the cost of novel therapies must account for changes in both the population that receives the novel therapy as well as the populations that do not (in this case, patients admitted to the ward). Changes in behavior such as lower thresholds to use new therapies and decreasing utilization of other therapies may impact the overall cost of treatment of the entire patient population. In our current study, accounting for the entire bronchiolitis population demonstrated continued lower costs associated with the ward HFNC. Riese et al[18] cite a decrease of $2920 in hospital charges, but charges are a poor surrogate for cost, so the true savings are challenging to interpret.[19,20] In contrast, our analysis used hospital cost in our model input, which is a strength of our study. Modeling charge and reimbursement data would perhaps have had greater implication to third-payer parties, but given our adherence to cost data, our data are most applicable to hospital administrators who seek to contain cost. If one were to extrapolate cost savings from our hospital to a national level by using data from 2009 that indicates ~118 000 children (without high-risk conditions) are admitted to the hospital annually, cost savings could be between $48 000 000 and $93 000 000 with a ward-based HFNC care model (based on our 95% CI of cost savings of $408–$795 per patient).[2]

Despite its strengths, this study is subject to limitations related to the model inputs. The initial probabilities and transition probabilities for patients in the ICU HFNC branch were partially based on our described assumptions. We attempt in our sensitivity analysis to mitigate uncertainty around the admission rate to the ICU on HFNC and provide a target for admission rates to achieve cost equivalence. Additionally, our study solely evaluates direct patient costs and does not account for costs related to development, maintenance, revision, and analysis of the clinical pathway. These were considered shared overhead costs among other pathways that were simultaneously being developed, maintained, and analyzed in the hospital; therefore, these costs were excluded from analysis.[21] The costs associated with the resultant increase in respiratory therapist personnel and HFNC equipment as a result of the pathway were unable to be quantified because of the

simultaneous increase in HFNC use across the hospital for many other patients (cardiac patients, chronic pulmonary patients, etc). The added cost of the RISK nurse's services is not captured in this model. However, the ward bronchiolitis patients on HFNC only represent a modest proportion of the RISK nurse's workload. Therefore, this cost was felt to be negligible. Further strategies to decrease ICU admissions and transfers, such as allowing higher flow rates with HFNC in the ward, would likely decrease costs for patients with bronchiolitis, which is a reasonable goal in this low-risk population whose intubation rate is <2% at our institution.

Given our institution's rapid practice change in favor of HFNC use without published randomized control trials (RCTs) to reference, we decided to use a decision analytic simulation model to evaluate our institution's practice as well as how outcomes might change under different assumptions (sensitivity analyses). The benefit of such models is that they can be adapted over time to incorporate new evidence from RCTs and additional clinical strategies, such as the use of HFNC versus low-flow oxygen in moderate bronchiolitis that was evaluated in an RCT by Kepreotes et al.[22] Interestingly, although the conclusion of the aforementioned study was that universally applied HFNC does not decrease time to weaning off oxygen or decrease LOS, the patients on HFNC had lower costs compared with those on low-flow oxygen (when crossover to HFNC was not allowed).[22] However, the details of the economic analysis are not disclosed and the authors characterize their analysis as an estimate, so it is difficult to judge the precision or accuracy of the costs that are reported.[22] Future attempts to evaluate the clinical benefit of HFNC in bronchiolitis, including completed trials from the University of British Columbia and the Children's Hospitals and Clinics of Minnesota, should report both cost and health outcomes in detail so that these data can be compared to and used as inputs for decision analytic models of ward-based HFNC strategies.[23–25]

Although the results of the model indicate economic benefits and decreased LOS with HFNC use in the ward, caution should be exercised in extrapolating the data to mean that HFNC improves outcomes in patients with bronchiolitis or that widespread use in mildly distressed patients is economically beneficial. HFNC remains an expensive therapy (with costs estimated to be ~$328 per day at our institution), and larger, more comprehensive studies are planned to determine if widespread HFNC use is associated with increased costs in bronchiolitis patients.[24] Moreover, comprehensive studies that help delineate which patients with bronchiolitis truly benefit from HFNC (with attention to appropriate flow rates and timing of use) would likely curtail overuse, which has the potential to have widespread economic benefits.

CONCLUSIONS

This simulation suggests that using HFNC in the general ward would decrease costs and LOS for patients with bronchiolitis. A national study seeking to trend the costs and clinical outcomes of hospitalized patients with bronchiolitis would be helpful to illustrate the economic effects of ubiquitous HFNC in this patient population.

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