# Variability of Intensive Care Management for Children With Bronchiolitis

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**KEY WORDS**
continuous positive airway pressure, high-flow nasal cannula, institutional variability, intraclass correlation coefficient, intubation, respiratory distress

**ABBREVIATIONS**
CBC: complete blood cell count
CI: confidence interval
CXR: chest radiograph
CPAP: continuous positive airway pressure
HFNC: high-flow nasal cannula
ICC: intraclass correlation coefficient
NIV: noninvasive ventilation
RDSS: respiratory distress severity score

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## abstract

**OBJECTIVE:** To determine the extent of variability in testing and treatment of children with bronchiolitis requiring intensive care.

**METHODS:** This prospective, multicenter observational study included 16 academic children's hospitals across the United States during the 2007 to 2010 fall and winter seasons. The study included children <2 years old hospitalized with bronchiolitis who required admission to the ICU and/or continuous positive airway pressure (CPAP) within 24 hours of admission. Among the 2207 enrolled patients with bronchiolitis, 342 children met inclusion criteria. Clinical data and nasopharyngeal aspirates were collected.

**RESULTS:** Respiratory distress severity scores and intraclass correlation coefficients were calculated. The study patients' median age was 2.6 months, and 59% were male. Across the 16 sites, the median respiratory distress severity score was 5.1 (interquartile range: 4.5–5.4; $P < .001$). The median value of the percentages for all sites using CPAP was 15% (range: 3%–100%), intubation was 26% (range: 0%–100%), and high-flow nasal cannula (HFNC) was 24% (range: 0%–94%). Adjusting for site-specific random effects (as well as children's demographic characteristics and severity of bronchiolitis), the intraclass correlation coefficient for CPAP and/or intubation was 21% (95% confidence interval: 8–44); for HFNC, it was 44.7% (95% confidence interval: 24–67).

**CONCLUSIONS:** In this multicenter study of children requiring intensive care for bronchiolitis, we identified substantial institutional variability in testing and treatment, including use of CPAP, intubation, and HFNC. These differences were not explained by between-site differences in patient characteristics, including severity of illness. Further research is needed to identify best practices for intensive care interventions for this major cause of pediatric hospitalization.

Bronchiolitis is the leading cause of hospitalization in infants, with ~125 000 to 150 000 hospitalizations each year in the United States.[1,2] Despite the prevalence of this disease, the management of children with bronchiolitis varies widely, both within and between institutions.[3–5] In 2006, the American Academy of Pediatrics recommended supportive care only for bronchiolitis[6]; there is no conclusive evidence for routine use of bronchodilators,[7] systemic corticosteroids,[8,9] or chest radiographs (CXRs).[10,11] Since publication of these recommendations, subsequent studies indicate a decreased use of steroids, bronchodilators, and radiography, as well as reduced viral antigen testing and resource utilization.[12–15]

However, the American Academy of Pediatrics consensus statement did not provide recommendations for the 10% to 16% of hospitalized children who require intensive care.[1,16] Although Willson et al[5] found that the threshold for intubation with bronchiolitis varied widely across 10 hospitals, they did not examine other respiratory modalities used in critically ill patients such as continuous positive airway pressure (CPAP) or high-flow nasal cannula (HFNC). Since the study by Willson et al was published, small prospective studies of between 12 and 29 children,[17–19] as well as 2 larger retrospective studies,[20,21] found that both CPAP and HFNC improved respiratory rates, oxygenation, and work of breathing in children with severe bronchiolitis. Unfortunately, current data to identify a subgroup that confers the greatest benefit are not available,[16,22] nor is there a consensus on objective measures to guide escalation of therapy. Management may be provider or institution driven, making comparisons across institutions a critical component in identifying areas needing further investigation. From 2000 to 2009, only 2% of hospitalized bronchiolitis patients required mechanical ventilation (noninvasive and invasive); however, these children accounted for 18% of the total annual costs.[23] Decreasing unnecessary variation and utilization of these costly interventions will thus have the largest impact on the expense of caring for children with severe bronchiolitis.

Numerous studies have attempted to describe the predictors of ICU admission or severe disease.[24–27] However, there are no multicenter studies specifically examining the variability in critical care management and treatment across different institutions. Data on site-to-site variability will aid in focusing research efforts toward development of evidence-based guidelines, thereby increasing patient safety and reducing cost. The focus of the present study was to examine variability in intensive care management among 16 large urban US medical centers for children hospitalized with bronchiolitis.

## METHODS

### Study Design

This prospective, multicenter cohort study was conducted for 3 consecutive years during the 2007–2010 winter seasons, as part of the Multicenter Airway Research Collaboration (MARC), a program of the Emergency Medicine Network (EMNet) (www.emnet-usa.org). For reference, detailed methods have been described previously.[27] Inclusion criteria consisted of an attending physician's diagnosis of bronchiolitis, age <2 years, and parental informed consent. The exclusion criteria were previous enrollment and transfer to a participating hospital >48 hours after the original admission time. Because we aimed to enroll 20% of our total sample from the ICU, the ward and ICU enrollments were therefore separate. Once the site reached its target enrollment for each month, enrollment stopped until the beginning of the next month.

### Data Collection

Investigators conducted a structured interview assessing children's demographic characteristics, medical and environmental history, duration of symptoms, and details of the acute illness. Details regarding birth history and any comorbid conditions were collected. Comorbid conditions included review of respiratory, cardiac, neurologic, gastrointestinal, and immunologic diseases. Preadmission evaluation (clinic or emergency department) and daily hospital clinical data, including respiratory rates with trends, assessment of retractions, oxygen saturation with trends, medical management, and disposition, were obtained by chart review. These data were manually reviewed at the EMNet coordinating center; site investigators were queried about any missing data, and discrepancies were identified.

To examine the variability in ICU care, ICU cases were defined as any patient admitted to the ICU and/or having received an ICU intervention (ie, CPAP and/or intubation) on their first inpatient day. Isolating this early ICU population allowed us to focus on a group of patients of great interest to treating clinicians. This group of patients was more likely to be clinically similar to each other and different from those who were initially treated in the ward and then later declined after a day of being hospitalized. Thus, these patients represented a more homogeneous subset of children, allowing better assessment of management variability according to sites. To evaluate bronchiolitis severity among children receiving early intensive care, a modified respiratory distress severity score (RDSS) was calculated by using 4 assessments made during the preadmission visit: respiratory rate, presence of wheezing (yes or no), air entry (normal, mild, or moderate/severe difficulty), and retractions (none, mild, or moderate/severe).[28] Each component was scored 0, 1, or 2, with the exception of wheeze, which was scored either 0 (no wheeze) or 2 (wheeze). These scores were summed for a total score between 0 and 8 (with 8 indicating the most severe distress).

### Statistical Analyses

All analyses were performed by using Stata version 11.2 (Stata Corp, College Station, TX). Data are presented as proportions with 95% confidence intervals (CIs), medians with interquartile ranges, or means with 95% CIs. When 1 of the RDSS components was missing, the Stata impute command was used to calculate the RDSS. Children missing data for >1 RDSS component were not assigned an RDSS. To assess ICU care variability, the association between study site and other factors was examined by using the $\chi^2$ test, Fisher's exact test, analysis of variance, and the Kruskal-Wallis test, where applicable. All $P$ values were 2-tailed, with $P < .05$ considered statistically significant.

The variability of test utilization and management interventions were quantified between sites (while assessing the effect of each child's characteristics) by creating 2 multilevel mixed effects logistic regression models for each test and treatment of interest and then calculating each model's corresponding intraclass correlation coefficient (ICC). The first models created for each test and management outcomes of interest accounted for random site effects but did not adjust for patient-level characteristics. The second set of complete models accounted for random site effects while simultaneously adjusting for patient-level characteristics (ie, age, gender, race, insurance provider, median household income according to zip code, RDSS, apnea). Therefore, the ICCs derived from our first models specifying only random site effects represent the proportion of the total treatment variation that is attributable to the site-level differences without adjusting for patient-level characteristics. The ICCs from our complete adjusted models represent the proportion of the total treatment variation that is attributable to the site-level differences after accounting for differences in patient-level characteristics. Comparing both models, the contribution of patient characteristics to the total outcome variation seen according to site would be reflected in a corresponding decrease in the adjusted ICC. ICC values are presented as proportions, with a possible range of 0% to 100%, which is interpreted as none (ie, 0%) up to all (ie, 100%) of the observed outcome variability being due to between-site differences.

## RESULTS

Among the 2207 enrolled subjects, 2104 (95%) had full disposition data. Of these 2104 children, 342 (16%) required ICU admission or CPAP and/or intubation within 24 hours of hospitalization. Individual sites contributed from 3 to 42 patients per site over the entire 3-year study period, with a mean and median of 21 patients per site. Demographic data, medical history, and clinical presentation are shown in Table 1. Among all children receiving early intensive care, the mean age was 2.6 months (95% CI: 1.2–7.3); 59% were male, 66% were white, and 35% were Hispanic. Most children were publicly insured (58%). Preterm infants comprised 29% of the study population; this finding did not differ by site ($P = .61$). Comorbid conditions and apnea at preadmission were present in 21% and 20% of all children, respectively, and were marginally associated with site (comorbid conditions, $P = .06$; apnea, $P = .08$). RDSS values were imputed for 36 patients; 31 patients did not have RDSS values imputed because they were missing ≥2 RDSS components. When comparing the imputed RDSS variable versus the nonimputed RDSS variable (calculated from children

**TABLE 1** Demographic Characteristics, Medical History, and Clinical Presentation of Children With Bronchiolitis Receiving Intensive Care

| Characteristic | Percentage (95% CI) Among All Children ($n = 342$) | Median (Range) Value of Percentages Among All Sites ($n = 16$) |
|---|---|---|
| Age, mo[a] | 2.6 (1.2–7.3) | 2.8 (1.1–9.5) |
| Male | 59 (53–64) | 58 (30–76) |
| White race | 66 (61–71) | 71 (23–100) |
| Hispanic | 35 (29–40) | 26 (0–100) |
| Insurance | | |
| Private | 36 (31–41) | 33 (0–82) |
| Public | 58 (53–63) | 64 (12–100) |
| None | 6 (3–8) | 5 (0–16) |
| Premature[b] | 29 (24–33) | 27 (13–50) |
| Parental asthma | 29 (24–33) | 27 (0–47) |
| Major relevant comorbid disorder | 21 (17–26) | 20 (0–40) |
| Fever[c] | 33 (27–38) | 31 (0–73) |
| RSV | 70 (66–75) | 71 (50–100) |
| HRV | 26 (21–30) | 25 (10–48) |
| Apnea at preadmission visit | 20 (16–25) | 18 (0–42) |
| RDSS[d] | 4.9 (4.7–5.1) | 5.1 (3.2–6.3) |

HRV, human rhinovirus; RSV, respiratory syncytial virus.
[a] Median (interquartile range).
[b] Defined as gestational age <37 weeks.
[c] Defined as temperature ≥100.4°F.
[d] Mean (95% CI).

with complete data), the overall mean RDSS was unchanged, and there was no material difference observed in the mean RDSS by site (data not shown). Thus, all RDSS results include the imputed values. The mean RDSS was 4.9 and ranged from 3.2 to 6.3 across the 16 study sites. Median length of stay in the ICU ranged from 2 to 6 days. No deaths occurred in this patient cohort.

Comparing data aggregated according to site, testing was common, with >75% of children having a complete blood cell count (CBC) and CXR performed at 14 and 13 sites, respectively. An intravenous line was placed in 93% of children. Regarding treatments, median use of inpatient corticosteroids across the sites was 33% (range: 19%–100%), and median use of inpatient antibiotics across sites was 64% (range: 33%–100%). Comparing preadmission use versus inpatient use of corticosteroids and antibiotics demonstrated an overall increase of 15% and 17%, respectively. Details of testing and treatments are shown in Table 2. Use of respiratory supportive therapies varied considerably according to site. The median use of CPAP alone was 15%, whereas the overall and median use of intubation was 26% (Figs 1 and 2, respectively). The median use of CPAP and/or intubation was 34% (range: 7%–100%). Median use of HFNC across sites was 24% (range: 0%–94%) (Fig 3).

Children who received the following treatments had higher mean RDSS values: bronchodilators (5.2 vs 4.4; $P = .01$), corticosteroids (5.4 vs 4.6; $P = .003$), and HFNC (5.4 vs 4.7; $P = .004$). However, CPAP/intubation was not associated with RDSS ($P = .33$). ICC values assessing intersite variation with and without adjustment for patient-level characteristics are presented in Table 3. Adjusting for children's characteristics had no material effect on the ICC (24%) for checking a CBC. ICC for bronchodilator use in both models showed no significant variation according to site. ICCs for inpatient corticosteroid and antibiotic use were consistently <1%, demonstrating almost no variation by site. In contrast, the ICC of the CPAP/intubation model with site-specific random effects remained high, even after adjusting for children's demographic characteristics and bronchiolitis severity (21.3% vs 20.9%). Examining CPAP and intubation separately revealed site variation as well (Figs 1 and 2), with ICCs of 27.9% and 14.8%, respectively, in the models only adjusted for site effects. When adjusting for patient characteristics, the ICC for CPAP changed minimally, whereas the ICC for intubation exhibited a modest decrease (7.2%). These data demonstrate substantial site variability in the use of CPAP and/or intubation that is not explained by differences in patient-level characteristics. Use of HFNC had the highest ICC that was sustained even after adjustment for children's characteristics and severity (42.5% vs 44.7%) (Fig 3). Given that 1 site contributed only 3 patients to the study, the ICC variability analyses were repeated by excluding this outlier site, but results did not materially change (data not shown).

## DISCUSSION

In this multicenter, prospective study of bronchiolitis patients requiring intensive care, we found substantial institution-level variation in diagnostic testing and, more importantly, in the use of CPAP, intubation, and HFNC. The variation in care between sites persisted even after controlling for multiple factors, including demographic characteristics, medical history, and disease severity. Our data strongly suggest the need for further research to develop evidence-based

**TABLE 2** Diagnostic Tests and Treatments Administered to Children With Bronchiolitis Receiving Intensive Care

| Test and Treatment | Visit | Percentage (95% CI) Among All Children ($n = 342$) | Median (Range) Value of Percentages Among All Sites ( ($n = 16$) |
|---|---|---|---|
| CBC | Preadmission or inpatient | 79 (75–83) | 82 (39–100) |
| CXR | Preadmission or inpatient | 87 (83–90) | 91 (63–100) |
| Bronchodilators | Preadmission | 67 (62–72) | 69 (38–100) |
| | Inpatient | 60 (54–65) | 64 (36–87) |
| Corticosteroids | Preadmission | 18 (13–22) | 18 (0–50) |
| | Inpatient | 33 (28–38) | 33 (19–100) |
| Antibiotics | Preadmission | 46 (40–51) | 47 (20–95) |
| | Inpatient | 63 (58–68) | 64 (33–100) |
| CPAP | Inpatient | 21 (17–26) | 15 (3–100) |
| Intubation | Inpatient | 26 (22–31) | 26 (0–100) |
| CPAP and/or intubation | Inpatient | 38 (33–43) | 34 (7–100) |
| HFNC | Inpatient | 33 (28–38) | 24 (0–94) |

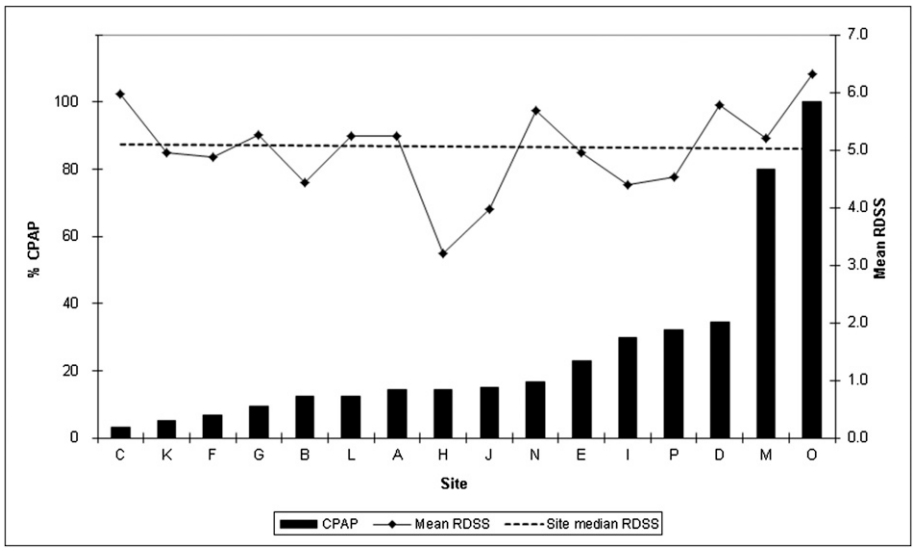


**FIGURE 1** Proportion of bronchiolitis patients according to site who received CPAP within 24 hours of admission.

guidelines that improve clinical outcomes while decreasing unnecessary resource utilization.

Based on national data, Hasegawa et al[23] reported a 21% increase (1.9% to 2.3%) in use of mechanical ventilation between 2000 and 2009 for bronchiolitis. Given the total volume of >325 000 patients hospitalized with bronchiolitis reported in this study, a 21% increase is of great importance. Notably, the authors did not distinguish between invasive ventilation (ie, intubation) and noninvasive ventilation (ie, CPAP). Considering our overall rates of CPAP (21%) and HFNC (33%) across 16 sites, we subjectively believe this trend is largely reflective of increased use of noninvasive ventilation (NIV). These distinctions are particularly important given that 2 single-site studies concluded that increasing NIV over time led to decreasing rates of intubation.[29,30]

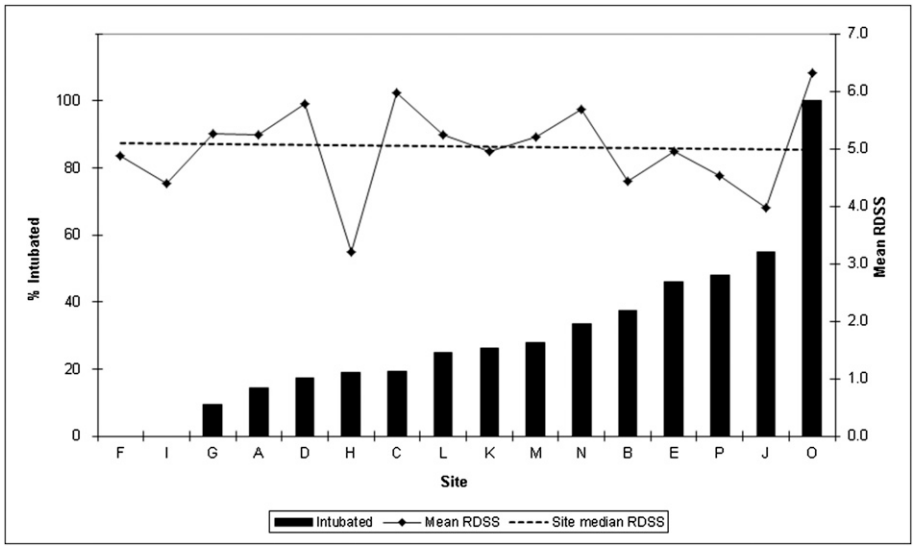


**FIGURE 2** Proportion of patients with bronchiolitis according to site who were intubated within 24 hours of admission.

Overall, the evidence demonstrating the effectiveness of CPAP and HFNC for bronchiolitis is limited. Although CPAP trials have shown promising results with decreases in respiratory distress,[17,18,20] a comprehensive review of CPAP for bronchiolitis was inconclusive due to the low quality of the evidence.[31] Evidence for HFNC is also limited, with a retrospective single-site study comparing children before and after introduction of HFNC in the ICU demonstrating a decreased rate of both intubation and ICU length of stay.[21] A prospective study of 21 children showed increased pharyngeal pressures that resulted in reduced respiratory effort.[19] Two systemic reviews suggest that HFNC is well tolerated, but there was insufficient evidence to determine its effectiveness.[32,33] Given that HFNC is not superior to positive pressure ventilation, clinical indications require further clarification.[33]

Our data reflect the lack of guidelines for physicians regarding initiation or escalation of CPAP or HFNC. Specific characteristics of children most likely to benefit from either modality are also unknown. For bronchiolitis, studies have attempted to validate objective respiratory scoring systems for research and early clinical practice.[34,35] However, a respiratory severity scoring system has not been validated against end points relevant to critical care, which would be useful for guiding escalation decisions.[36] Similar findings have been reported regarding variability in critical care treatment of severe asthma

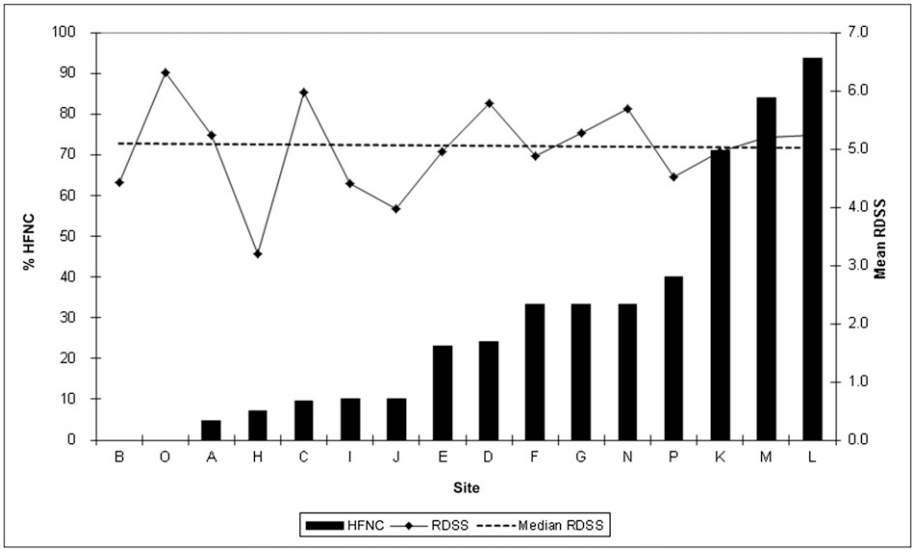


**FIGURE 3** Proportion of patients with bronchiolitis according to site who received HFNC within 24 hours of admission.

exacerbations; namely, a lack of high-quality research and need for objective respiratory scoring relevant to the critically ill. Overall, our data highlight the need for further examination of mechanical ventilation (eg, CPAP, intubation) and HFNC in bronchiolitis to identify indications, objective escalation criteria, and safety profiles.

When solid data to provide guidance are lacking, variability in care ensues, as demonstrated by our findings from16 different US sites. This variability persisted with minimal change in the ICC even after controlling for age, demographic characteristics, and severity of illness (including apnea). Although CPAP and HFNC require special equipment and properly trained staff, which may differ substantially between institutions, this availability cannot fully explain the differences across large academic medical centers. We recognize that the use of CPAP or HFNC for bronchiolitis may have been initiated (or discontinued) at specific sites during our study period, which potentially affects subsequent intubation rates. This change in practice can lead to varying utilization, reflecting clinician experience and familiarity with use of these interventions specific to this disease. This finding further supports the lack of consensus regarding proper use of these modalities in this early ICU population. Our data suggest that clinicians across 16 institutions, when faced with similar clinical presentations, chose different respiratory supportive modalities specifically in the setting of acute respiratory decompensation within 24 hours.

From 2000 to 2009, national hospital charges for children with bronchiolitis increased 30% from $1.34 billion to $1.75 billion, despite decreased hospitalizations.[23] Mortality rates have also decreased over the past decade. Children with risk factors including prematurity, very low birth weight, or comorbid conditions are more likely to be admitted to the ICU[16,37–39] and

**TABLE 3** ICC Assessing Between-Site Variability in the Use of Tests and Treatments Given to Children With Bronchiolitis Who Received Intensive Care, With and Without Adjustment For Children's Characteristics

| Test and Treatment | Visit | Adjusted for Site Random Effects Only | | Adjusted for Site Random Effects and Children's Characteristics[a] | |
|---|---|---|---|---|---|
| | | ICC (%) | 95% CI | ICC (%) | 95% CI |
| CBC | Preadmission or inpatient | 24.2 | 9.3–49.9 | 20.7 | 7.1–47.2 |
| CXR | Preadmission or inpatient | 17.1 | 4.8–45.6 | 11.8 | 2.2–43.6 |
| Nebulized bronchodilators | Preadmission | 0.5 | 0.0–98.7 | 0.0 | NC |
| Nebulized bronchodilators | Inpatient | 8.4 | 2.6–24.1 | 6.4 | 1.3–26.5 |
| Corticosteroids | Preadmission | 17.4 | 4.8–46.5 | 10.8 | 1.3–53.4 |
| Corticosteroids | Inpatient | 0.8 | 0.0–60.8 | 0.0 | 0.0–100 |
| Antibiotics | Preadmission | 9.7 | 2.9–28.1 | 8.8 | 2.3–28.4 |
| Antibiotics | Inpatient | 0 | NC | 0.7 | 0.0–96.53 |
| CPAP | Inpatient | 27.9 | 12.3–51.6 | 24.6 | 9.3–51.0 |
| Intubation | Inpatient | 14.8 | 4.2–40.6 | 7.6 | 1.1–36.8 |
| CPAP and/or intubation | Inpatient | 21.3 | 8.9–42.7 | 20.9 | 8.2–43.9 |
| HFNC | Inpatient | 42.5 | 22.6–65.1 | 44.7 | 24.0–67.4 |

CXR, chest radiograph; NC, not calculable.
[a] Age, gender, race, insurance, median household income according to zip code, RDSS, and presence of apnea.

represent a higher percentage of bronchiolitis admissions in recent national trends.[23] It is unclear if these risk factors contribute to earlier and more frequent use of NIV at specific sites or if better outcomes are seen in this population with NIV. It is also unclear if there is a causal relationship between increased use of NIV and decreased mortality rates. In the present study, there were no significant differences in prematurity, age, or comorbid conditions across sites to fully explain the variability in use of different methods of mechanical ventilation. Reducing variability by using quality improvement methods has been effective for the care of noncritically ill children with bronchiolitis[12–15,40] and could be successfully used in the critical population as well.

Although the majority of the costs of caring for patients with severe bronchiolitis resided with mechanical ventilation, variability in care was also evident in diagnostic testing. There are no clear indications for obtaining a CBC for bronchiolitis.[41] Some clinicians may argue that critically ill children require more testing, but it is worth mentioning this variability because it is also possible some tests add to unnecessary charges and blood draws.[42] In the present study, there was a clear discrepancy between sites ordering a CBC, with a range of 39% to 100% not explained by age. Although infants aged <2 months routinely have more extensive evaluation for fever, median age was consistent across sites. CXRs were also obtained in most children in this study, with substantial between-site variation. Although previous research questions the necessity and cost-effectiveness of CXRs in bronchiolitis,[10,11,43] other data suggest this uncertainty applies to children with mild or moderate distress and oxygen saturations >92%,[11] which may not represent the present cohort. CXRs must be individually considered for those not following a standard course[10,44] and are also typically obtained after intubation. Despite this consideration, our data show similar percentages of comorbid conditions at each site and minimal change in adjusted ICC, indicating that patient characteristics or severity of respiratory distress does not fully explain this variability.

In this severely ill population, the median use of corticosteroids at each site almost doubled from the preadmission visit to the inpatient setting (18% vs 33%). A similar pattern was seen for antibiotics, with use increasing from 47% at preadmission to 64% at the inpatient period. These increases are notable given the lack of indication for either treatment in bronchiolitis. Although there is no clear guidance regarding the use of corticosteroids, including for intubated children with respiratory syncytial virus bronchiolitis,[45] 15 of 16 sites reported increased use comparing inpatient with preadmission rates. Our study included children aged up to 2 years, which could overlap with cases of undiagnosed reactive airway disease, but our early intensive care cohort comprised almost entirely infants (overall mean age: 2.6 months). Furthermore, despite the low risk of bacterial coinfections and previous studies encouraging decreased utilization of antibiotics,[46,47] 14 of the 16 sites reported higher inpatient antibiotic use. One study of 23 infants did suggest that early empirical antibiotics may be justified in this population presenting with respiratory failure because of a higher risk of concomitant bacterial pneumonia.[48] Corticosteroid and antibiotic use did not exhibit site-specific ICC variation, indicating increased use was not attributed to specific sites but rather most sites increased utilization in a potentially decompensating patient. Similarly, a review of ICU management for pediatric asthma showed increased use of medications not routinely recommended and with little supportive evidence.[36] We speculate that in the face of limited guidance on outcomes in this population, sites justifiably may try other medications, including corticosteroids and antibiotics, in an attempt to treat severely ill children showing signs of rapid respiratory decline.

Our study has several potential limitations. Although we focused on common clinical elements, tests, and treatments, the study sites were large urban medical centers and the results may not be generalizable to community hospitals. In addition, indications for initiating antibiotics vary, particularly in more acutely ill patients with rapid decline and concern for secondary infection. Comorbid conditions were likewise included and may have influenced certain treatment decisions, but they were present in a similar percentage at each site. Imputation of the RDSS was required for only 36 observations and was performed when only 1 component of the RDSS was missing. Sensitivity analyses suggest this imputation did not introduce significant bias. The exact timing of the RDSS may not have coincided with sudden rapid decline leading to escalation in respiratory support but was within 24 hours. For this reason, the ICC was calculated, which includes several factors rather than the RDSS alone, for clearer comparisons between institutions. Lastly, criteria for ICU admission or transfer

out of the ICU differ across institutions and by site-specific resources. As a result, the severity of respiratory distress may not have been the reason for ICU admission or transfer to a lower level of care, which would affect meaningful interpretation of ICU length of stay. However, this study provides a valuable snapshot of intensive care resource utilization for a large number of infants at 16 sites across the United States.

## CONCLUSIONS

In this multicenter, multiyear prospective study of children with bronchiolitis requiring ICU-level care within 24 hours of admission, we found substantial between-site variability in utilization of CPAP, intubation, and HFNC that was not explained by differences in severity of illness or patient characteristics. There is overall increasing use of these respiratory supportive modalities in the setting of decreasing mortality but rising costs of bronchiolitis hospitalization. Considering the impact of increasing costs in this common pediatric illness, further research is needed to generate evidence that can better provide guidance to clinicians and thereby reduce between-site variability. The ultimate goal of such guidelines would be to improve clinical outcomes while decreasing unnecessary resource utilization.

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