Published in final edited form as:

Pediatr Infect Dis J. 2018 June ; 37(6): 514–519. doi:10.1097/INF.0000000000001836.

Discharge Criteria for Bronchiolitis: An Unmet Need

Cristina Garcia-Mauriño, MD¹, Melissa Moore-Clingenpeel, MA, MAS², Rebecca Wallihan, MD³, Katalin Koranyi, MD³, Bavani Rajah, BS¹, Tiffany Shirk, BSN³, Maria Vegh, MSN³, Octavio Ramilo, MD^{1,3}, and Asuncion Mejias, MD, PhD^{1,3,*}

¹Center for Vaccines and Immunity, Nationwide Children's Hospital and The Ohio State University College of Medicine, Columbus, OH

²Biostatistics Core, The Research Institute at Nationwide Children's Hospital, Nationwide Children's Hospital and The Ohio State University College of Medicine, Columbus, OH

³Division of Pediatric Infectious Diseases, Nationwide Children's Hospital and The Ohio State University College of Medicine, Columbus, OH

Keywords

Bronchiolitis; discharge criteria; clinical outcomes

INTRODUCTION

Bronchiolitis is the leading cause of hospitalization in infants in USA.(1) Different guidelines for the management of children with bronchiolitis have been published.(2–4) Most of these guidelines are focused on admission criteria and the value (or not) of different therapeutic interventions during hospitalization. However, there are no standardized protocols for the discharge of infants and young children with bronchiolitis.

Of all parameters influencing patient discharge, thresholds for discontinuation of oxygen supplementation represent one of the major determinants.(5–7) However, oxygen weaning pathways, as well as the desired thresholds for oxygen discontinuation vary according to the different guidelines. (4, 8–10) These factors may contribute to the wide variability in length of stay reported among different institutions, both in USA and across the world.(11, 12) Standardizing clinical criteria for bronchiolitis is especially relevant in an era where new interventions for prevention and treatment of RSV infection are being evaluated in clinical studies. (13–16)

The aim of this study was to assess the impact of a standardized discharge protocol for bronchiolitis on clinical outcomes. The protocol included both an oxygen weaning pathway and objective clinical criteria.

*Corresponding author: Asuncion Mejias, MD, PhD, MsCS, Center for Vaccines and Immunity, The Research Institute at Nationwide Children's Hospital, 700 Children's Drive, WA 4022, Columbus, OH 43205, USA. The Ohio State University, Phone: 614-355-2949. Fax: 614-722-3680, Asuncion.Mejias@nationwidechildrens.org.

Conflict of Interest: The remaining authors do not declare any conflicts of interest.

METHODS

Study design

In October 2013, a protocol for the discharge of children with bronchiolitis was implemented in the Infectious Diseases (ID) unit at Nationwide Children's Hospital (NCH) but not in other hospital units (non-ID) caring for these children. This protocol included both precise clinical discharge criteria and an oxygen weaning pathway. Before its implementation, the protocol was discussed with all medical staff in the ID unit including residents, attending physicians and registered nurses, and goals for discharge documented daily in patients' electronic health records (EHR). The impact of the discharge protocol was retrospectively assessed by comparing: a) length of hospitalization, and b) readmission rates within two weeks, in children hospitalized and discharged from the ID vs. non-ID units during two respiratory seasons following the implementation of the protocol. Compliance with the discharge protocol was indirectly assessed by randomly auditing the adherence to the oxygen weaning pathway in 10% of patients' electronic health records (EHR).

The decision to hospitalize patients to ID (ID unit) or to the general pediatrics or pulmonary services (non-ID units) was made at the discretion of the Emergency Department physician, and based on bed availability. A small number of patients were directly admitted to NCH from outside facilities (ID, 6% and non-ID units, 8%). The pediatric intensive care unit (PICU) was not included in the 'non-ID units' group, as patients were rarely discharged directly from the PICU. Admission to the intensive care unit was decided at the discretion of the PICU attending physician and PICU practices were consistent throughout the study. NCH is affiliated with The Ohio State University and it is the only tertiary care children's hospital in Central Ohio. All units in the hospital are resident based, and nursing teams are exclusive for each unit.

Discharge Protocol—The parameters and criteria included in the discharge protocol are summarized in SDC Table 1. Transcutaneous oxygen saturation (SpO₂) 90% was the threshold used to discontinue oxygen. Details regarding the O₂ weaning pathway are shown in Figure 1 SDC. For patients with abnormal baseline oxygen saturation or requiring home oxygen, the SpO₂ threshold was adjusted. Continuous pulse oximetry was standard of care at the time of the study.

Patient identification—Electronic Health Records (EHR) from children < 2 years of age discharged with a primary diagnosis of bronchiolitis, were identified by the International Classification of Diseases (ICD)-9 codes (466.11, RSV bronchiolitis; 466.19, bronchiolitis attributed to other infectious organisms) and data crosschecked with virology laboratory results. Viral testing was performed at the discretion of the attending physicians across the hospital, and systematically per standard of care in the ID unit. Testing was mostly PCR based; either a laboratory developed real-time PCR or a multiplex PCR panel (FilmArray Respiratory Panel; BioFire, Salt Lake City, UT).(17) EHR were reviewed for demographic and clinical data including presence of comorbidities, which were categorized in: prematurity, congenital heart disease, chronic lung disease, immunodeficiency, neuromuscular disorders and genetic syndromes.(18–21) Information regarding length of

stay, need and duration of PICU stay, mechanical ventilation, and hospital readmissions was also collected. For patients with multiple hospitalizations for bronchiolitis/lower respiratory tract infections (LRTI), only the first admission during the same respiratory season was analyzed. The study was approved by the NCH Institutional Review Board.

Statistical analysis

Patient characteristics were compared using Wilcoxon rank-sum test for continuous variables and chi-square test for categorical variables, and data presented as medians (25th–75th interquartile ranges) or frequencies (percentages) accordingly. The Bonferroni correction was applied to adjust for multiple testing when analyzing variables that included multiple categories. For multivariable analyses, we selected as primary outcomes length of stay (LOS), and readmission rates. Given that the distribution of LOS was skewed, gamma regression with a log link function was used, after verifying goodness of fit with residual plots and deviance statistics. All gamma regression coefficients were exponentiated to allow for interpretation in terms of risk ratios.(22) Logistic regression was used to determine which factors were associated with readmission rates. Variable selection was based on significance on bivariate analyses, and clinical grounds. Analyses were conducted using SAS 9.3 (SAS Institute, Cary, NC) and GraphPad Prism v.6 (GraphPad Software; La Jolla, CA), with a two-sided p-value <0.05 considered statistically significant.

RESULTS

Patient Characteristics

From October 2013 to May 2015, 1,813 children < 2 years of age were hospitalized with bronchiolitis at NCH. Of those, 1,118 were discharged from the ID unit, and 695 from non-ID units. The demographic characteristics of these children are shown in Table 1. Children discharged from the ID unit were younger and 23% were black compared to 29% in non-ID units, where presence of comorbidities was more frequent. The most common underlying condition in both units was prematurity. Gender and type of medical health insurance was similar in both groups.

Viral testing was performed in 92.7% of children, 1,103 (98.5%) and 578 (83%) in ID vs. non-ID units respectively (p<.001). RSV alone, or in combination with other respiratory viruses was identified in 76% of children.

In terms of disease severity, 29% of children discharged from ID vs. 36% from non-ID units required PICU admission (p=0.009), with no differences in duration of PICU stay (3 [2–5.73] vs. 3 [2–6] days; p=0.86) or need for mechanical ventilation (6.2% vs. 7.6%; p=0.24) in ID and non-ID units respectively.

Length of stay and readmissions according to discharge unit

To determine the value of the discharge protocol we compared length of stay and readmission rates within two weeks of discharge between units. Protocol compliance in the ID unit, indirectly assessed by adherence to the oxygen weaning pathway, was 97% [68%–100%]. Total LOS, which included ward and PICU stay for children that required PICU

admission, was shorter in children discharged from the ID unit (ID, 2.0 [1.4–3.8] vs. non-ID, 2.8 [1.7–4.9] days; $p<.001$). Likewise, LOS exclusively in the ward (excluding PICU stay) was also shorter in children discharged from ID versus non-ID units (1.7 [1.1–2.5] vs. 2 [1.2–3.3] days, respectively; $p<.001$; Figure 1). Ten children were directly discharged from the PICU and were not included in the analyses. Sensitivity analyses in which patients with comorbidities were excluded showed similar results (Figure 1).

There were no differences in readmissions rates between units (2.9% ($n=33/1118$) in ID vs. 2.6% ($n=18/695$) for non-ID units; $p=0.77$). Readmitted children were younger (2.3 vs. 4.9 months; $p<0.001$), and had lower weights than patients who were not readmitted to the hospital within two weeks of discharge (SDC Table 2).

Independent predictors of clinical outcomes

To confirm the findings derived from bivariate analyses, we constructed multivariable models using as primary outcomes: length of stay (total [PICU + ward] and ward exclusively), and readmission rates. Discharge unit (ID vs. non-ID), age, gender, race/ethnicity, presence of comorbidities, viral etiology and PICU admission were included as covariates. In addition, because the presence of comorbidities was more common in children discharged from non-ID units, and admission to the PICU could per se influence the outcomes selected, further sensitivity analyses excluding children with comorbidities and stratifying by PICU admission were conducted.

A) Length of stay—Race, presence of comorbidities, RSV+ status, PICU admission and discharge from non-ID units, were all independent risk factors for longer LOS (Table 2). The same covariates independently increased the risk of longer LOS exclusively in the ward (after time in the PICU was excluded from the analysis). Overall, children hospitalized in non-ID units had both a total hospital stay and a ward only stay 36% to 42% longer than patients discharged from the ID unit respectively.

A second set of analyses in which children with comorbidities were excluded, showed that the same covariates except race independently increased the risk for total longer LOS. However, the only factor associated with longer LOS exclusively in the ward was discharge from non-ID units. Healthy children discharged from non-ID units had a total and ward hospital stay ~30% longer than those discharged from the ID unit. Sensitivity analysis including only children <12 months of age, which represented the majority (85% (946/1118) in ID and 73% (509/695) in non-ID units), confirmed that discharge from non-ID units was independently associated with longer total and ward LOS (data not shown).

Last, to account for the possible carry-over effect of PICU admission when analyzing ward LOS, we performed sensitivity analyses excluding from the analyses children who required PICU admission. Adjusted ratios were calculated first including all patients (healthy children + children with comorbidities) and then excluding children with comorbidities. Children who did not require PICU admission and were discharged from non-ID units consistently showed an increased risk for longer LOS (all patients; RR: 1.38 [1.28–1.50]; $p<0.001$; healthy children: RR: 1.28 [1.18–1.40]; $p<0.001$).

C) Readmissions rates—After adjusting for other covariates, the odds of hospital readmission were greater in infants of younger age [1.13-fold increase risk per month decreased in age (OR=0.87 [0.80–0.94]; $p=0.04$)], but were not influenced by the discharge unit (Table 3).

DISCUSSION

In this single center study, we assessed the value of a standardized discharge protocol for young children hospitalized with bronchiolitis, which included both an oxygen weaning pathway and objective clinical criteria. Implementation of the protocol was associated with reduced length of stay without increasing the rates of readmission.

Over the past years different studies and guidelines for the management of bronchiolitis have been published.(5, 23, 24) These guidelines provide recommendations in terms of prevention, diagnosis, admission criteria, and management of hospitalized children with bronchiolitis with little or no information regarding discharge criteria, which may contribute to the wide variability in length of stay reported among different studies.(2, 4, 8, 10, 25, 26)

Of all parameters influencing patient discharge, and thus length of stay, the threshold for oxygen discontinuation represent one of the main determinants.(5–7) The 2015 United Kingdom NICE guidelines, mentioned in general terms the need for clinical stability, adequate oral intake, and SpO₂ >92% for patient discharge; while the 2006 Scottish Guidelines established a SpO₂ threshold of >94%, and required >75% of usual oral intake, regardless of age. Recent studies have shown that oxygen discontinuation when SpO₂ are 90% is safe and associated with improved outcomes.(5, 6, 27) The 90% oxygen threshold is currently recommended by the Finnish and the 2014 American Academy of Pediatrics guidelines, and was the threshold used in our protocol.(2, 25) In addition, we considered that standardizing the oxygen weaning process was a central component of the protocol, that possibly helped minimize variability of time to spO₂ discontinuation. Data regarding other objective clinical parameters that that could influence a timely and safe discharge of children with bronchiolitis are scarce. Recently a large prospective study evaluated in detail the clinical course of children < 2 years of age hospitalized with bronchiolitis.(28) Authors identified four parameters that could be used as discharge criteria including: improving retractions, stable respiratory rate, SpO₂ >90%, and good hydration status.(29, 30) In addition to those four parameters, we included having adequate follow up as a key criterion for discharge planning, which has special relevance in the youngest age group. Young age was identified as a risk factor for hospital readmission in our study, emphasizing the need for early and adequate follow-up of these children.(31–33)

Studies suggest that implementation of objective criteria for patient discharge may improve clinical outcomes.(34–37) In children with bronchiolitis, clinical pathways have been traditionally focused on patient management. Utilization of these pathways have been associated with a reduction on resource utilization (chest-x rays, albuterol or steroid use) with variable results in terms of clinical outcomes.(34–36, 38–40) A study comparing a cohort of 229 infants with bronchiolitis who were managed based on a clinical pathway, with a historical cohort of 207 children managed without the pathway, showed that protocol

adherence was associated with decreased readmission rates with no impact on length of hospital stay.(35) More recently, a retrospective study showed how adherence to a standardized clinical pathway in 267 children with bronchiolitis was associated with shorter length of stay in the emergency department (ED), with no significant differences in hospital stay.(36) Contrary to those studies, we found that the implementation of a discharge protocol significantly reduced length of stay with no increase in readmission rates. These discrepancies may be related to differences in the populations included and study design, since thresholds to discontinue supplemental oxygen, acceptable duration without oxygen therapy or admissible oral intake at discharge were not homogeneous or completely addressed. Nevertheless, the present study, which included a larger sample size, used a stringent spO2 threshold ($\geq 90\%$), a detailed oxygen weaning pathway and five additional clinical criteria, emphasize the value of such protocols not only for patient management, but for patient discharge. Standardizing discharge criteria for bronchiolitis may help reduce the wide variability in length of stay that exists among different countries and even across institutions within the same country.(11, 12, 41, 42) A reduction in duration of hospitalization can bring important benefits not only for patients but also for healthcare facilities, as it decreases the risk of nosocomial infections, the likelihood of medical errors and hospital costs, and allows a more efficient bed turnover.(43) In addition to these objective outcomes, others not so easy to measure but important potential benefits of a timely discharge, include reestablishing the infant's and family routine, which in turn may help patient recovery.

This study has limitations. Given the integral design of a retrospective analysis, it is possible that unmeasured confounders may have influenced the results. Although the evaluation of the discharge criteria was adjusted for a number of variables, there are other factors that are intrinsic to the hospitalization units. Comparing outcomes before and after the protocol implementation in the ID unit could control for this potential bias. However, as bronchiolitis is a common pediatric condition with no specific antiviral therapy, it could be argued that a contemporary parallel comparison between different units would better assess the effect of the protocol, leaving aside the reported differences in disease severity over different seasons that could influence length of stay.(44, 45) Another limitation is that the clinical pathway was designed for otherwise healthy children, and certain thresholds established in the protocol may not apply to children with underlying medical conditions, which will warrant individual assessment. Nevertheless, sensitivity analyses that included only healthy children, who represented the majority of hospitalized children(46), confirmed the positive impact of the standardized discharge criteria.

In summary, we propose a standardized protocol for the discharge of children with bronchiolitis, which has the potential to impact patient management by decreasing unnecessary hospital stay.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Source of Funding: AM has received research grants from NIH (#AI112524) and Janssen; fees for participation in advisory boards from Janssen, and fees for lectures from Abbvie and Novartis. OR has received research grants from Janssen and NIH (#AI112524); fees for participation in advisory boards from Janssen, Abbvie, HuMabs, Medimmune and Regeneron; and fees for lectures from Abbvie. The Research Institute has received institutional support from NIH (#UL1 TR001070). Those grants and fees were not related to the research described in this manuscript.

Abbreviations

ID	Infectious diseases
LOS	length of stay
RSV	respiratory syncytial virus
PICU	Pediatric Intensive Care Unit
ED	Emergency Department
NCH	Nationwide Children's Hospital
EHR	electronic health records

BIBLIOGRAPHY

1. Yorita KL, Holman RC, Sejvar JJ, Steiner CA, Schonberger LB. Infectious disease hospitalizations among infants in the United States. *Pediatrics*. 2008; 121:244–252. [PubMed: 18245414]
2. Ralston SL, Lieberthal AS, Meissner HC, Ralston SL, Lieberthal AS, Meissner HC, et al. Clinical Practice Guideline: The Diagnosis, Management, and Prevention of Bronchiolitis. *Pediatrics*. 2014;134(5):e1474–e1502. *Pediatrics*. 2015; 136:782.
3. Ricci V, Delgado Nunes V, Murphy MS, Cunningham S, Guideline Development G, Technical T. Bronchiolitis in children: summary of NICE guidance. *BMJ*. 2015; 350:h2305. [PubMed: 26037525]
4. Caffrey Osvald E, Clarke JR. NICE clinical guideline: bronchiolitis in children. *Arch Dis Child Educ Pract Ed*. 2016; 101:46–48. [PubMed: 26628507]
5. Schuh S, Freedman S, Coates A, et al. Effect of oximetry on hospitalization in bronchiolitis: a randomized clinical trial. *JAMA*. 2014; 312:712–718. [PubMed: 25138332]
6. Unger S, Cunningham S. Effect of oxygen supplementation on length of stay for infants hospitalized with acute viral bronchiolitis. *Pediatrics*. 2008; 121:470–475. [PubMed: 18310194]
7. Schroeder AR, Marmor AK, Pantell RH, Newman TB. Impact of pulse oximetry and oxygen therapy on length of stay in bronchiolitis hospitalizations. *Archives of pediatrics & adolescent medicine*. 2004; 158:527–530. [PubMed: 15184214]
8. Friedman JN, Rieder MJ, Walton JM. Bronchiolitis: Recommendations for diagnosis, monitoring and management of children one to 24 months of age. *Paediatrics & child health*. 2014; 19:485–498. [PubMed: 25414585]
9. Ralston SL, Lieberthal AS, Meissner HC, et al. Clinical practice guideline: the diagnosis, management, and prevention of bronchiolitis. *Pediatrics*. 2014; 134:e1474–1502. [PubMed: 25349312]
10. O'Donnell DR, Openshaw PJ. Anaphylactic sensitization to aeroantigen during respiratory virus infection. *Clin Exp Allergy*. 1998; 28:1501–1508. [PubMed: 10024221]
11. Cheung CR, Smith H, Thurland K, Duncan H, Semple MG. Population variation in admission rates and duration of inpatient stay for bronchiolitis in England. *Archives of disease in childhood*. 2013; 98:57–59. [PubMed: 23220210]

12. Macias CG, Mansbach JM, Fisher ES, et al. Variability in inpatient management of children hospitalized with bronchiolitis. *Acad Pediatr*. 2015; 15:69–76. [PubMed: 25444654]
13. DeVincenzo JP, Whitley RJ, Mackman RL, et al. Oral GS-5806 activity in a respiratory syncytial virus challenge study. *N Engl J Med*. 2014; 371:711–722. [PubMed: 25140957]
14. DeVincenzo JP, McClure MW, Fry J. ALS-008176 for Respiratory Syncytial Virus Infection. *N Engl J Med*. 2016; 374:1391–1392.
15. Mejias A, Garcia-Maurino C, Rodriguez-Fernandez R, Peeples ME, Ramilo O. Development and clinical applications of novel antibodies for prevention and treatment of respiratory syncytial virus infection. *Vaccine*. 2017; 35:496–502. [PubMed: 27692523]
16. Mazur NI, Martinon-Torres F, Baraldi E, et al. Lower respiratory tract infection caused by respiratory syncytial virus: current management and new therapeutics. *Lancet Respir Med*. 2015; 3:888–900. [PubMed: 26411809]
17. Moyer K, Wang H, Salamon D, Leber A, Mejias A. Enterovirus D68 in Hospitalized Children: Sequence Variation, Viral Loads and Clinical Outcomes. *PloS one*. 2016; 11:e0167111. [PubMed: 27875593]
18. Welliver RC. Review of epidemiology and clinical risk factors for severe respiratory syncytial virus (RSV) infection. *The Journal of pediatrics*. 2003; 143:S112–117. [PubMed: 14615709]
19. Rossi GA, Medici MC, Arcangeletti MC, et al. Risk factors for severe RSV-induced lower respiratory tract infection over four consecutive epidemics. *European journal of pediatrics*. 2007; 166:1267–1272. [PubMed: 17308898]
20. Thorburn K. Pre-existing disease is associated with a significantly higher risk of death in severe respiratory syncytial virus infection. *Archives of disease in childhood*. 2009; 94:99–103. [PubMed: 18653625]
21. Alvarez AE, Marson FA, Bertuzzo CS, Arns CW, Ribeiro JD. Epidemiological and genetic characteristics associated with the severity of acute viral bronchiolitis by respiratory syncytial virus. *Jornal de pediatria*. 2013; 89:531–543. [PubMed: 24035870]
22. McCullagh, PNAJ. Generalized linear models. *CRC Monographs on Statistics & Applied Probability*. second. 1989.
23. Corneli HM, Zorc JJ, Mahajan P, et al. A multicenter, randomized, controlled trial of dexamethasone for bronchiolitis. *N Engl J Med*. 2007; 357:331–339. [PubMed: 17652648]
24. Ramilo O, Lagos R, Saez-Llorens X, et al. Motavizumab treatment of infants hospitalized with respiratory syncytial virus infection does not decrease viral load or severity of illness. *Pediatr Infect Dis J*. 2014; 33:703–709. [PubMed: 24356256]
25. Tapiainen T, Aittoniemi J, Immonen J, et al. Finnish guidelines for the treatment of laryngitis, wheezing bronchitis and bronchiolitis in children. *Acta paediatrica (Oslo, Norway: 1992)*. 2016; 105:44–49.
26. Baraldi E, Lanari M, Manzoni P, et al. Inter-society consensus document on treatment and prevention of bronchiolitis in newborns and infants. *Italian Journal of Pediatrics*. 2014; 40
27. Cunningham S, Rodriguez A, Adams T, et al. Oxygen saturation targets in infants with bronchiolitis (BIDS): a double-blind, randomised, equivalence trial. *Lancet (London, England)*. 2015; 386:1041–1048.
28. Mansbach JM, Clark S, Piedra PA, et al. Hospital course and discharge criteria for children hospitalized with bronchiolitis. *Journal of hospital medicine*. 2015; 10:205–211. [PubMed: 25627657]
29. Hasegawa K, Tsugawa Y, Brown DF, Mansbach JM, Camargo CA Jr. Trends in bronchiolitis hospitalizations in the United States, 2000–2009. *Pediatrics*. 2013; 132:28–36. [PubMed: 23733801]
30. Hasegawa K, Tsugawa Y, Brown DF, Mansbach JM, Camargo CA Jr. Temporal trends in emergency department visits for bronchiolitis in the United States, 2006 to 2010. *The Pediatric infectious disease journal*. 2014; 33:11–18. [PubMed: 23934206]
31. Hain PD, Gay JC, Berutti TW, Whitney GM, Wang W, Saville BR. Preventability of early readmissions at a children's hospital. *Pediatrics*. 2013; 131:e171–181. [PubMed: 23230064]

32. Morse RB, Hall M, Fieldston ES, et al. Children's hospitals with shorter lengths of stay do not have higher readmission rates. *The Journal of pediatrics*. 2013; 163:1034–1038.e1031. [PubMed: 23683748]
33. Alverson BK, O'Callaghan J. Hospital readmission: quality indicator or statistical inevitability? *Pediatrics*. 2013; 132:569–570. [PubMed: 23979087]
34. White CM, Statile AM, White DL, et al. Using quality improvement to optimise paediatric discharge efficiency. *BMJ quality & safety*. 2014; 23:428–436.
35. Cheney J, Barber S, Altamirano L, et al. A clinical pathway for bronchiolitis is effective in reducing readmission rates. *The Journal of pediatrics*. 2005; 147:622–626. [PubMed: 16291352]
36. Bryan MA, Desai AD, Wilson L, Wright DR, Mangione-Smith R. Association of Bronchiolitis Clinical Pathway Adherence With Length of Stay and Costs. *Pediatrics*. 2017; 139
37. Mittal V, Darnell C, Walsh B, et al. Inpatient bronchiolitis guideline implementation and resource utilization. *Pediatrics*. 2014; 133:e730–737. [PubMed: 24534398]
38. Mittal V, Hall M, Morse R, et al. Impact of inpatient bronchiolitis clinical practice guideline implementation on testing and treatment. *J Pediatr*. 2014; 165:570–576 e573. [PubMed: 24961787]
39. Parikh K, Hall M, Teach SJ. Bronchiolitis management before and after the AAP guidelines. *Pediatrics*. 2014; 133:e1–7. [PubMed: 24298006]
40. McCulloh RJ, Smitherman SE, Koehn KL, Alverson BK. Assessing the impact of national guidelines on the management of children hospitalized for acute bronchiolitis. *Pediatr Pulmonol*. 2014; 49:688–694. [PubMed: 23868897]
41. Behrendt CE, Decker MD, Burch DJ, Watson PH. International variation in the management of infants hospitalized with respiratory syncytial virus. International RSV Study Group. *European journal of pediatrics*. 1998; 157:215–220. [PubMed: 9537488]
42. Srivastava R, Stone BL, Patel R, et al. Delays in discharge in a tertiary care pediatric hospital. *Journal of hospital medicine*. 2009; 4:481–485. [PubMed: 19824097]
43. McBride SC, Chiang VW, Goldmann DA, Landrigan CP. Preventable adverse events in infants hospitalized with bronchiolitis. *Pediatrics*. 2005; 116:603–608. [PubMed: 16140699]
44. Waris M. Pattern of respiratory syncytial virus epidemics in Finland: two-year cycles with alternating prevalence of groups A and B. *J Infect Dis*. 1991; 163:464–469. [PubMed: 1995719]
45. Panozzo CA, Fowlkes AL, Anderson LJ. Variation in timing of respiratory syncytial virus outbreaks: lessons from national surveillance. *Pediatr Infect Dis J*. 2007; 26:S41–45. [PubMed: 18090199]
46. Hall CB, Weinberg GA, Iwane MK, et al. The burden of respiratory syncytial virus infection in young children. *N Engl J Med*. 2009; 360:588–598. [PubMed: 19196675]

Figure 1. Length of hospital stay (LOS) in children with bronchiolitis according to the presence of comorbidities and admission unit

Blue bars represent values for children hospitalized in non-ID units and grey bars for those in ID units. Dotted line separates analyses excluding LOS in the PICU and children with comorbidities. Data is expressed as medians [25%–75% IQR]. Mann-Whitney test $p < 0.05$.

Table 1

Demographic and virology data based on the discharge unit

Variable	ID Unit (n=1118)	Non-ID Units (n=695)	a p -value
Demographic characteristics			
Age (months)	4 (1.8–8.5)	6.5 (2.5–12)	<. .001
Sex (male)	612 (55%)	395 (57%)	.40
GA (weeks)	39 (37–40)	39 (36.8–40)	.009 *
Race/Ethnicity			
Black, non-Hispanic	257 (23%)	201 (29%)	.04
White, non-Hispanic	661 (59%)	380 (55%)	
Hispanic	65 (6%)	31 (4%)	
Other/Unknown	135 (12%)	83 (12%)	
Health Insurance type			
Medicaid	768 (69%)	494 (71%)	.18
Private	306 (27%)	184 (26%)	
Other/unknown	44 (4%)	17 (3%)	
Comorbidities	262 (23.5%)	237 (34%)	<. .001
-Prematurity (week's GA)	212 (81%)	170 (72%)	.12
<37–32 wk	174 (82%)	112 (66%)	<. .001
<32–29 wk	27 (13%)	24 (14%)	>.99
<29 wk	11 (5%)	34 (20%)	<. .001
- CLD	15 (6%)	22 (9%)	>.99
- CHD	14 (5%)	21 (9%)	.90
- Immunodeficiency	0	6 (2.5%)	N/A
- Genetic syndromes	21 (8%)	15 (6.5%)	>.99
- Neuromuscular disorders	0	3 (1%)	N/A
Virology data			
Single pathogen detection			
▪ RSV	534 (58%)	254 (54%)	.09
▪ RV	88 (9.5%)	66 (14%)	
▪ Metapneumovirus	43 (4.5%)	16 (3%)	
▪ Parainfluenza	19 (2%)	10 (2.1%)	
▪ Adenovirus	9 (1%)	2 (0.4%)	
▪ Influenza A/B	7 (0.8%)	1 (0.2%)	
▪ Coronavirus	4 (0.7%)	3 (1%)	
Co-infections	178 (19%)	94 (20%)	.97
No virus	44 (5%)	28 (6%)	.72

Categorical data is expressed as frequency (%) and analyzed using Fisher's or chi-square test. Continuous data is expressed as medians (25%–75% interquartile range) and analyzed using Mann-Whitney Rank Sum test. ID: infectious diseases; GA: gestational age; CLD: chronic lung disease; CHD: congenital heart disease; IDs: immunodeficiency; ND: Neuromuscular disorders; RSV: respiratory syncytial virus; RV: rhinovirus; Co-infections: more than one respiratory virus identified. The Bonferroni correction was applied to correct for multiple testing when analyzing variables that included multiple categories such as presence of comorbidities (p values reflect the adjusted values; p-values).

* Effect size calculated (based on Cliff's delta) for the difference in gestational age by unit [0.08 (0.03,0.14)] considered negligible.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 2

Adjusted Risks for total and ward length of hospital stay in children with and without additional comorbidities

Variable	All children		Healthy children	
	Risk Ratio [upper- lower CL]	p-value	Risk Ratio [upper- lower CL]	p-value
Total LOS (PICU+ward)				
Age (months)	0.98 [0.92–1.05]	.54	1.00 [0.99–1.01]	.96
Gender *	1.03 [0.97–1.09]	.40	0.99 [0.92–1.06]	.71
Race/Ethnicity**				
Black	1.20 [1.04–1.38]	.02	1.17 [1.00–1.37]	.05
White	1.23 [1.07–1.40]	.004	1.15 [0.98–1.34]	.07
Others	1.15 [0.98–1.35]	.08	1.08 [0.91–1.28]	.39
Comorbidities	1.37 [1.27–1.46]	<.001	NA	NA
RSV positive	1.11 [1.03–1.20]	.005	1.10 [1.01–1.20]	.02
PICU Admission	3.13 [2.93–3.35]	<.001	2.96 [2.75–3.18]	<.001
Non-ID units *	1.35 [1.27–1.44]	<.001	1.25 [1.16–1.35]	<.001
Ward LOS				
Age (months)	1.00 [0.99–1.00]	.40	1.00 [0.99–1.01]	.37
Gender *	1.05 [0.99–1.13]	.11	1.02 [0.95–1.10]	.60
Race/Ethnicity				
Black	1.12 [0.96–1.31]	.16	1.17 [0.99–1.40]	0.07
White	1.16 [1.00–1.35]	.04	1.13 [0.96–1.34]	0.15
Others	1.15 [0.97–1.37]	.11	1.12 [0.93–1.35]	0.24
Comorbidities	1.40 [1.30–1.52]	<.001	NA	NA
RSV positive	1.13 [1.05–1.23]	.001	1.09 [1.00–1.20]	.05
Non-ID units *	1.42 [1.32–1.53]	<.001	1.28 [1.18–1.39]	<.001

LOS: length of stay; PICU: pediatric intensive care unit. Reference parameters for gender was male, for race/ethnicity: Hispanic, for RSV+ status: patients who underwent viral testing and were negative for RSV, and for non-ID:

* ID unit; CL: confidence limit. NA: not applicable.

Table 3

Adjusted risk of readmission in children with and without comorbidities

Variable	All children		Healthy children	
	Odds Ratio [upper- lower CL]	p-value	Odds Ratio [upper- lower CL]	p-value
Age (months)	0.87 [0.80–0.94]	.004	0.67[0.55–0.82]	<.001
Female	1.02 [0.57–1.82]	.96	1.72 [0.83–3.55]	.15
Race/Ethnicity				
Black	0.80 [0.25–2.53]	.70	1.33 [0.26–6.71]	.73
White	0.58 [0.20–1.73]	.33	0.84 [1.80–3.88]	.82
Others	0.43 [0.10–1.77]	.24	0.20 [0.02–2.35]	.20
Any Comorbidity	1.24 [0.66–2.36]	.51	NA	NA
RSV positive	0.51 [0.27–0.96]	.04	0.46 [0.19–1.10]	.07
PICU Admission	0.94 [0.50–1.76]	.85	1.11 [0.51–2.42]	.79
Non-ID	1.08 [0.57–1.97]	.86	0.83 [0.36–1.90]	.66

Reference parameters for gender were female, for race/ethnicity: Hispanic, for RSV+ status: patients who underwent viral testing and were negative for RSV, and for non-ID:

* ID unit; CL: confidence limit