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Alexandra Carver Crampton	12/15/2024

Use of Bronchodilators in the Management of Bronchiolitis

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NRSG-728D: DNP Scholarly Project III

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Contents

Introduction

Background

Bronchiolitis, or inflammation of the bronchioles of the lungs, is the "most common lower respiratory tract infection in children younger than 2 years of age" (Erickson et al., 2023). Due to the already small airways of children in this age group, the inflammation associated with bronchiolitis can lead to obstruction, respiratory distress, and decreased oral intake. For these reasons, "bronchiolitis is one of the leading causes of hospitalization in children under 1 year of age, with approximately 100,000 bronchiolitis admissions and $1.73 billion annual costs in the United States (US)" (Bolick et al., 2021, p. 929). On admission, one symptom that may be noted in those with bronchiolitis is the presence of a wheeze. This wheeze is a result of obstruction of the airway due to increased mucus production, inflammation, and cellular necrosis, and appears to have little to do with smooth muscle constriction (Erickson et al., 2023; Bower & McBride, 2015). Subsequently, there is little evidence to support the use of bronchodilators in the treatment of bronchiolitis, and as such in 2014 the American Academy of Pediatrics (AAP) strongly recommended against the use of bronchodilators in the updated bronchiolitis guidelines (Ralston et al., 2014). However, despite these recommendations, a varied approach to the management of bronchiolitis remains, and bronchodilators continue to be used frequently in the management of bronchiolitis (Spindler et al., 2023).

Significance

Bronchiolitis is most common during the first two years of life with a peak incidence between three months to six months of age. It occurs due to a viral infection and while many viruses are associated with bronchiolitis, respiratory syncytial virus (RSV) is the most common, accounting for 50% to 80% of cases (Bolick et al., 2021, p. 929). RSV is typically present from

the months of December through March and leads to “2.1 million outpatient (non-hospitalization) visits among children younger than 5 years old each year…and 100-300 deaths in children younger than 5 years old” (*Center for Disease Control (CDC)*, 2024). While death is uncommon, there are several risk factors that increase the risk for severe disease or complications including: “chronological age, male sex, chronic co-existing medical conditions, prematurity, low birth weight, immunodeficiency, exposure to cigarette smoke, lower socioeconomic status, lack of breastfeeding, and exposure to crowded environments” (Bolick et al., 2021, p. 929). One study showed that many variables associated with lower socioeconomic status, including access to care, infrastructure variables, neighborhood density, sanitation, and pollution, may explain why incident rates of RSV-associated hospitalization are higher in census-tracts with high levels of poverty (Holmen et al., 2021).

While the rates of bronchodilator use in the US have “declined from 90% in 2007-2012 to 25% in 2017” (Cahill & Cohen, 2018), a study performed by Schuh et al., (2017) found that of infants hospitalized with bronchiolitis, more than 30% did not receive evidence-based treatment during their stay.” While several children’s hospitals report having bronchiolitis protocols, others rely on providers to make decisions regarding treatment options.

The use of bronchodilators in the treatment of bronchiolitis has long been controversial. However, current guidelines recommend against the use of bronchodilators for treatment and instead recommend supportive care measures such as supplemental oxygen, intravenous fluids, and suctioning (Ralston et al., 2014). This is because the use of bronchodilators in infants with bronchiolitis has not been shown to be beneficial in management as it does not decrease admission rates, length of stay, or shorten the days infants experience symptoms (Erickson et al., 2023). Furthermore, a recent study showed that administering bronchodilators in these infants

may be harmful. This is because the use of bronchodilators may lead to further ventilation-perfusion (V/Q) mismatch, increasing the need for supplemental oxygen (Del Vecchio et al., 2012). For these reasons, the purpose of this integrative review is to determine the current use of bronchodilators for the management of bronchiolitis, determine potential outcomes associated with use, and investigate interventions that may lead to a decrease in the use of these medications.

Project Aim

This integrative review further investigates the current use of bronchodilators in the management of bronchiolitis, as well as risk factors that may be associated with increased use. Additionally, potential outcomes associated with the administration of bronchodilators are investigated. Finally, interventions to decrease the use of these bronchodilators are explored.

Clinical Questions

The clinical questions include: How often are bronchodilators being used in the management of bronchiolitis? What are the risk factors associated with an increased administration of bronchodilators? What are the health outcomes associated with bronchodilator treatment? Finally, what interventions may be useful in decreasing bronchodilator administration in this patient population?

Project Objectives

At the conclusion of this review, we aim to better understand the current use of bronchodilators for the management of bronchiolitis in the clinical setting, in addition to the outcomes associated with their use. Additionally, we aim to have a clearer understanding of interventions that may be used to decrease the use of bronchodilators for bronchiolitis management.

Assumptions and Limitations

There are a few assumptions and limitations that may arise while conducting this review. As this is an integrative review, study designs and methodologies utilized by various researchers have been combined, which may lead to problems with accuracy and bias (Toronto & Remington, 2020). Additionally, given that many of the research articles analyzed in this review contain data from retrospective chart reviews, it should be assumed that not all data was accurately recorded. Some providers may fail to document a full history on admission. Furthermore, patient parents may be unwilling to provide answers to such questions.

Theoretical Framework

The use of bronchodilators as an appropriate treatment for bronchiolitis has long varied across medical providers. Some providers theorize it is best to administer bronchodilators early in care, while some feel that there is no added benefit to administering these medications at all. Additionally, some feel that if no improvements in the patient status have been observed, a trial of bronchodilators is appropriate.

There are many reasons why providers may believe the use of bronchodilators early in care is beneficial. One reason is bronchiolitis may not be a single disease, but rather may have different endotypes and phenotypes (Petrarca et al., 2022). It is theorized that some of these phenotypes are strongly associated with the development of asthma, and that patients with these phenotypes may be experiencing their first asthma-exacerbation, rather than just having “pure” bronchiolitis. In these patients, it is felt that improvement may be seen with asthma type therapy, including the use of bronchodilators (Bottau et al., 2022).

While not all agree that administering bronchodilators early in the case is appropriate, some feel that they should be considered on a trial basis (Kirilos et al., 2020). A few children’s

hospitals in the United States have theorized the possible benefits of administering bronchodilator therapy in children that are severely ill (Seattle Children's Hospital, n.d). As such, a one-time trial of bronchodilator administration, with close monitoring, has been added to bronchiolitis management pathways.

In 2014, the AAP guidelines recommended against the use of bronchodilators. This guideline was updated after several systemic and meta-analyses showed that there was no improvement in patient outcomes after administration of these medications. Instead it is theorized that these medications can actually lead to patient harm, unnecessary medical costs, and increased oxygen consumption (Wolf et al., 2021). This is thought to be due to an increased likelihood for these patients to experience a (V/Q) mismatch, leading to hypoxemia (Del Vecchio et al., 2012).

This research project utilizes the Treatment Theory and Enablement Theory. In combination, these theories can provide guides for inducing clinical change through specifying mechanisms in which a treatment may produce change, as well as provide insight into the impact of these changes on other areas of function (Whyte, 2014). While this combination of theories is utilized most when regarding patient rehabilitation, it can contribute to studies related to healthcare treatments. This is because it works to improve treatment modalities through relation to the specific characteristics of a patient. This project aims to investigate the current use of bronchodilators in bronchiolitis as well as the impacts of these medications on children that present with bronchiolitis. The AAP recommendations should support the study hypothesis, that children that present with bronchiolitis and receive bronchodilators will have increased adverse outcomes compared to those who did not receive bronchodilator therapy. The goal of this project is to determine the current use of bronchodilators for bronchiolitis, determine risk factors that

may be associated with increased use, determine outcomes associated with use, and utilize the project findings to recommend interventions to decrease current use.

Methods

Population/Sample/Setting

The population for this integrative review will include pediatric patients from 15 articles discussing the use and efficacy of bronchodilators in bronchiolitis. Articles reviewed will contain a sample population of children aged two years or less with a billing or discharge diagnosis of bronchiolitis or RSV. Studies may include data collected between the years of 2002 to 2024, however, research must have been published in the last ten years.

Inclusion/Exclusion Criteria

Inclusion Criteria:

Research studies will be included in this integrative review if the study population involves children that are two years of age or less with a diagnosis of bronchiolitis or RSV. Studies that include patients with a diagnosis of lower respiratory tract infection, pneumonia, or wheezing may be included if researchers have taken appropriate covariates into consideration with analysis. Additionally, articles will be included for patients seen in the ED or that were treated in an inpatient setting in general or pediatric hospitals. Finally, articles will be included if they were published in the last ten years.

Exclusion Criteria:

Articles will be excluded from this integrative review if the sample population includes children older than two years of age. In addition, articles will be excluded if the sample population includes children with asthma, croup, or other respiratory conditions not described above. Articles will be excluded if they do not focus on the current use, efficacy and outcomes,

or interventions to decrease use of bronchodilators. Finally, articles that discuss combination therapy, such as bronchodilators with epinephrine or bronchodilators with hypertonic saline, will be excluded if an evaluation of bronchodilator therapy alone is not included.

Literature Search

A literature search was completed using the following databases: PubMed, Cumulative Index of Nursing and Allied Health Literature (CINAHL), Embase, and Web of Science. The terms "bronchiolitis," "respiratory syncytial virus," and "RSV" were combined with the terms "bronchodilator*," "albuterol," and "salbutamol." In addition, the terms "guideline*," "protocol*," "manage*," and "treatment*" were included in the search. Full-text, original research articles published between 2014 and 2024 were included in the review. A search of the database led to 2,102 records, of which 1,059 were excluded as they were older than ten years old or had no English version available (Appendix 1). An additional 456 duplicate records were removed, leaving 587 articles for title and abstract screening. Of those records, 123 full-text articles were assessed for eligibility. Studies were included if the sample population included children aged two years or less with a diagnosis of bronchiolitis or RSV that were seen in an inpatient or ED setting. Studies were excluded if they did not discuss the current use of bronchodilators in the management of bronchiolitis, efficacy or outcomes associated with the use of bronchodilators in bronchiolitis, or interventions to decrease the use of bronchodilators for bronchiolitis. Additionally, articles were excluded if they included combined treatment approaches without discussing albuterol use alone. A total of 15 studies were included in this literature review (Appendix 2). Results of the literature search were sorted into three of the following primary themes: Current use of bronchodilator therapy in those with bronchiolitis,

efficacy and outcomes of bronchodilator use in bronchiolitis, and interventions to decrease use of bronchodilator therapy in those with bronchiolitis.

Resources

Clinical resources include the DNP project practice partner, Dr. Courtney James, and available system resources. The project resource team will include the Emory University DNP course lead, Dr. Shawana Moore. Emory University Libraries will be available for external literature resources, and software (covidence) through the library will be used to help with data analysis.

Identification of Key Stakeholders and Site Support

The key stakeholders of this project include Riley Hospital for Children's research council, clinical managers, clinical directors, patient population, patient family, staff providers, and clinical staff.

Plan for Dissemination to Key Stakeholders

The findings of this integrative review support the hypothesis that the use of bronchodilators for bronchiolitis do not lead to significant improvements in patient outcomes. Furthermore, it describes interventions that may be used by end users to decrease unnecessary use of bronchodilators in the management of bronchiolitis.

My primary end users include the members of the Riley Research Council, the pulmonology and hospitalist providers, and nursing staff. I plan to involve users in my dissemination efforts by encouraging participation and collaboration among providers for a common goal, to improve patient care (Ross-Hellauer et al., 2020). I can use the following individuals and organizations to help; Riley Research Council, Dr. Nadia Krupp (staff pulmonologist), Dr. Richelle Baker (staff hospitalist). The ways that I can communicate the

results include publication on an academic social network such as ResearchGate, publication in online journals, and in person dissemination using attractive data displays (Ross-Hellauer et al., 2020).

Potential obstacles that I may face in disseminating my research include a lack of effective and efficient communication, lack of institutional support, and lack of funding (McElfish et al., 2019). I can mitigate these obstacles by presenting my findings in a clear, concise manner, maintaining strong relationships with the research council and staff providers, and utilizing methods of dissemination that have low costs. I plan to evaluate the dissemination plan by measuring results with a combination of quantitative indicators, such as the production and circulation of printed materials, and qualitative indicators such as feedback from the target groups (Ross-Hellauer et al., 2020). I plan to encourage feedback from the end users and dissemination partners by utilizing simple questionnaires and assessments and will provide feedback to them via in-person discussion.

Examining Bronchodilator Use in Bronchiolitis

Bronchiolitis is an inflammation of the respiratory tract and lungs, more specifically the bronchioles. It is usually due to an acute viral illness, most notably respiratory syncytial virus (RSV), however it may also be caused by parainfluenza, influenza, and adenovirus (Erickson et al., 2023). It is the most common respiratory tract infection globally in those under two years of age and has been estimated to cause “34 million acute lower respiratory tract infections in young children annually, with over 3 million severe cases requiring hospitalization, and between 66,000 to 199,000 fatalities…” *(World Health Organization (WHO)*, 2017).

Symptoms of bronchiolitis may include runny nose, nasal congestion, cough, tachypnea, the use of accessory muscles, and wheezing (Erickson et al., 2023). The respiratory symptoms

associated with bronchiolitis occur due to inflammatory processes leading to ciliary dysfunction, cell death, accumulation of debris, and edema of the airways (Justice & Le, 2023), and appear to have little to do with smooth muscle constriction (Bower & McBride, 2015). In 2014, a systematic review involving 30 trials was done to assess the effects of bronchodilators on clinical outcomes in infants with bronchiolitis. This review determined that bronchodilators "do not improve oxygen saturation, do not reduce hospital admission after outpatient treatment, do not shorten the duration of hospitalization, and do not reduce the time to resolution of illness…and instead may lead to increased adverse effects and expenses" (Gadomski & Scribani, 2014). Furthermore, another study showed that the use of bronchodilators in bronchiolitis may lead to further ventilation-perfusion (V//Q) mismatch, increasing the need for supplemental oxygen. For these reasons, in 2014 the American Academy of Pediatrics (AAP) updated their bronchiolitis guidelines, strongly recommending against the use of bronchodilators in the treatment of bronchiolitis (Ralston et al., 2014).

Despite these updated guidelines, a varied approach to the management of bronchiolitis still occurs, and it was noted that "rates of bronchodilator use in viral bronchiolitis range from 18% to 90%..." (Nino et al., 2020). Some providers advocate against the use of bronchodilators, instead opting for more symptomatic management. They feel that bronchodilators can lead to patient harm, unnecessary medical costs, and increased oxygen consumption (Wolf et al., 2021). Others feel that individuals with bronchiolitis have differing endotypes and phenotypes, and that infants with certain phenotypes may be experiencing an asthma exacerbation, rather than just bronchiolitis alone. In these patients it is felt that early administration of a bronchodilator can lead to improvement in patient outcomes (Bottau et al., 2022). Others feel that there are varying types of bronchiolitis, with variations occurring at both an individual and viral level. Providers

with this belief feel that infants with viral bronchiolitis presenting with wheezing and retractions would benefit from a therapeutic trial of bronchodilator administration (Nino et al., 2020).

Currently, many hospitals have a varying approach to bronchiolitis management. For this reason, the purpose of this integrative review is to determine the current use of bronchodilators in bronchiolitis, and the effect, if any, of bronchodilator use in bronchiolitis. It will also allow further examination of interventions to decrease the use of bronchodilator therapy in those with bronchiolitis.

Current Use of Bronchodilator Therapy in Those with Bronchiolitis

Six recent studies focused on the current use of bronchodilator therapy in those with bronchiolitis (Gong et al., 2019; Hester et al., 2021; House et al., 2021; Huang et al., 2024; Rivera-Sepulveda et al., 2019; Spindler et al., 2023). As previously discussed, in 2014 the AAP released updated bronchiolitis guidelines recommending against the use of bronchodilators in the management of bronchiolitis. However, provider approach to this guideline remains varied. A recent retrospective cohort study performed by Hester et al., (2021) used the Pediatric Health Information System (PHIS) database to collect data on bronchiolitis encounters from 52 children's hospitals across the United States (US). A total of 198,028 patients aged one month to two years with bronchiolitis or respiratory syncytial virus pneumonia were included in the study. Encounters were excluded if they occurred within 30 days of an initial encounter, if they included an intensive care unit (ICU) stay or a stay longer than 7 days, if the patient had any complex medical conditions as defined by Feudtner’s classification, or if the encounter had concurrent diagnosis of croup, pneumonia, or asthma. After the data was analyzed, researchers found that 19.3% of emergency department (ED) encounters and 32.7% of admission encounters were nonadherent with bronchiolitis bronchodilator guidelines. They also found that older

patients, non-Hispanic Black patients, and those being seen for a secondary encounter were more likely to be prescribed bronchodilators, while American Indians were less likely to receive bronchodilator therapy. In addition, it was determined that pediatric emergency medicine physicians were more likely to initiate bronchodilator therapy than pediatricians, nurse practitioners, and physician's assistants (Hester et al., 2021). To further examine factors associated with increased use of bronchodilators in the management of bronchiolitis, Huang et al., (2024) performed a retrospective cohort study using Colorado All Payer Claims data. Encounters were included in the study if they involved children less than two years old with a lower respiratory tract infection or wheezing-related visit and were excluded if the child had a previous or concurrent diagnosis of asthma. Analysis revealed that 14.4% of the study participants had a bronchodilator claim at or within seven days of the diagnosis. Additionally, it was determined that bronchodilator prescriptions were associated with male sex, older age, non-inpatient settings, atopy, public insurance, and prior bronchodilator or steroid claims. A history of complex chronic conditions or a family history of asthma did not show any significant association with bronchodilator prescription (Huang et al., 2024). Another retrospective study performed by Spindler et al., (2023) compared bronchiolitis management between standard-risk and high-risk patients with bronchiolitis, to determine if a difference in bronchodilator management could be seen. Researchers performed the study in an academic tertiary-care children's hospital and included patients that were less than two years old and admitted to the general pediatric unit between October 2016 and March 2019 with a diagnosis of bronchiolitis. Patients were defined as high-risk if they were born prematurely (gestational age less than 35 weeks), if they were less than 12 weeks at the time of admission, or if they had the presence of comorbidities such as chronic lung disease, congenital heart disease, neuromuscular disease, or

immunodeficiency. The study showed that patients in the standard-risk group were more likely to receive albuterol than those in the high-risk group (standard-risk 65.6% vs. high-risk 44.1%). Additionally, reports showed that the use of more than three doses was 28.7% in the standard-risk group, while the use of more than three doses in the high-risk group was 23.8%. When reviewed in combination, these studies describe the current use of bronchodilators for the management of bronchiolitis, as well as factors that may be associated with an increased use in certain populations.

Similarly, Gong et al., (2019), used a cross-sectional study with weighted frequency distributions to examine differences in bronchiolitis management between general EDs (GEDs) and pediatric EDs (PEDs). Data for this study was obtained using the National Hospital Ambulatory Medical Care Survey and included patients less than 24 months old that presented to an ED with bronchiolitis between the years of 2002 to 2011. Authors found that more patients with bronchiolitis were treated in GEDs, however the patients that were treated in PEDs were more likely to receive bronchodilators for the management of bronchiolitis (weighted percentages of 48.6% vs. 69%). Additionally, it was determined that in both GEDs and PEDs, no significant change in bronchodilator use occurred after the publication of the AAP national guidelines in 2006 (Gong et al., 2019). Rivera-Sepulveda et al., (2019) further explored the use of bronchodilators in the ED setting via a cross-sectional survey. The survey was distributed to members of the AAP Section on Emergency Medicine that practiced pediatric emergency medicine at the time of distribution. A total of 214 physicians completed the survey for a response rate of 47%. Of these physicians, 97.7% reported that they were aware of the current AAP bronchiolitis guidelines, however further analysis revealed that only 8.9% of participants had not prescribed bronchodilators for bronchiolitis in their practice, with 43% reporting rare

use. In addition, 40.7% of participants reported some use of bronchodilators in the management of bronchiolitis, while 7.4% reported use most of or all of the time (Rivera-Sepulveda et al., 2019). In combination, these studies provide some insight into the current use of bronchodilator therapy in the ED setting.

In contrast, a retrospective cohort study performed by House et al., 2021, found that the rates of bronchodilator use in the US have decreased since the publication of the AAP guidelines in 2006, with a further decrease since the release of the updated guidelines in 2014. Researchers included 602,375 bronchiolitis encounters from the PHIS database of children aged 28 days to two years with a discharge date from November 2006 to December 2019. Results showed a 13.5% decrease in ED use of bronchodilators and an 11.3% decrease in inpatient use of bronchodilators from the original publication of the AAP guidelines in 2006 to the publication of the update in 2014. Furthermore, both the ED and inpatient areas saw an improvement in adherence to bronchiolitis guidelines regarding bronchodilators, as evidenced by continued steepening of the negative monthly trajectory (-0.11% to 0.26% and –0.08% to –0.26%) (House et al., 2021). This study provides evidence that while nonadherence to bronchiolitis guidelines remains, rates of bronchodilator use have decreased since the original publication of the guidelines.

Efficacy and Outcomes of Bronchodilator Use in Bronchiolitis

Four recent research studies focused on efficacy and outcomes of bronchodilators as a therapy for bronchiolitis (Cai et al., 2020; Maki et al., 2021; Pinto et al., 2016; Shanahan et al., 2021). In a multicenter retrospective study that included 446,696 infants less than 12 months of age, Shanahan et al., (2021) evaluated trends in bronchodilator use, as well as various outcomes among hospitals with both high and low early use of bronchodilators. Of the 446,696 encounters

included in the study, a total of 111,310 (56,852 at a hospital with high rates of use and 54,458 at a hospital with low rates of use) were analyzed when evaluating outcomes associated with high and low rates of early bronchodilator use in the management of bronchiolitis. The study revealed that there were no significant differences in hospital admissions, ICU admissions, ED return visits, rates of noninvasive ventilation, and rates of invasive ventilation in patients at hospitals with high versus low early use of bronchodilators (Shanahan et al., 2021). In addition, a study performed by Pinto et al., (2016) evaluated the association between various types of nebulized therapies, including nebulized albuterol alone, on the length of stay (LOS) in children with nonsevere bronchiolitis. Analysis revealed that the LOS for those who received nebulized albuterol alone was comparable to those who did not receive any inhaled therapies (43.2 hours vs. 44.1 hours). Combined, these studies provide evidence that administering bronchodilators for the management of bronchiolitis has no significant impact on bronchiolitis outcomes. A final study performed by Maki et al., (2021) evaluated the association between bronchodilator therapy and outcome measures such as frequency of return visits and pediatric emergency department LOS. This was done via a retrospective case control study that included 185 infants less than 12 months old who presented to the PED between December 2014 and April 2017 with a discharge diagnosis of bronchiolitis. After adjusting for other patient factors (age, acuity, gender, severe tachypnea, oxygen desaturation, and signs of dehydration) it was determined that the use of salbutamol was associated with an increased PED LOS (58.3 minutes, P=0.01). This further supports the hypothesis that early use of bronchodilators does not improve measurable outcomes and thus may not be an effective therapy for bronchiolitis.

Similarly, a meta-analysis performed by Cai et al., (2020) investigated the efficacy of salbutamol treatment in infants with bronchiolitis. The researchers used STATA version 12.0 to

analyze thirteen randomized control trials and found that salbutamol did not improve clinical severity scores, length of stay, or oxygen saturations in infants with bronchiolitis. They instead found that infants treated with salbutamol experienced a significant increase in respiratory rate (WMD 2.26 [95% CI 0.36-4.16]) and heart rate (WMD 12.15 [95% CI 9.24-15.07]) and failed to demonstrate a statistical improvement in oxygen saturations (WMD 0.20 [95% CI- 0.35 to 0.75]), or length of hospitalization (WMD 0.12 [95% CI- 0.32 to 0.56]) (Cai et al., 2020). This meta-analysis provides evidence that bronchodilator therapy in those with bronchiolitis may not lead to improvements in patient outcomes, but instead, may increase adverse events.

Interventions to Decrease Use of Bronchodilator Therapy in Those with Bronchiolitis

Five recent studies focused on interventions to decrease the use of bronchodilator therapy in those with bronchiolitis (Dowling et al., 2020; Dunn et al., 2020; Feder et al., 2019; Lawrence et al., 2023; Molloy et al., 2019). To reduce the use of bronchodilators in the ED setting, Lawrence et al., (2023) implemented multifaceted interventions that included educational sessions, monthly audit-feedback tools, and an electronic medical record (EMR) alert. The multifaceted intervention was assessed using an interrupted time series analysis that included data between May 2016 and August 2022, with an intervention date of February 2019. A decrease in bronchodilator orders from 6.89% pre-intervention to 3.23% post-intervention was seen. Additionally, researchers found that while the EMR alert was activated for 200 unique patients, 180 (90%) ultimately received bronchodilator therapy. Reasons for overriding the alert included a patient age close to 12 months, a previous response to bronchodilators, or a positive family history of asthma (Lawrence et al., 2023). Another study that investigated the impact of an audit-feedback tool on rates of bronchodilator use was performed by Dowling et al., (2020). These researchers provided physicians with an individual data report that characterized their

bronchiolitis management between April 2013 and April 2017. Providers were then able to attend two multidisciplinary, group-facilitated feedback sessions, one in November of 2017 and one in December of 2018. To assess the impact of the intervention, data was collected for six months following both group-facilitated feedback sessions. It was determined that of those not admitted to the hospital, 17.9% received salbutamol in the baseline period, while only 10.8% received salbutamol after the intervention period. Additionally, of those admitted to the hospital, 21.1% received salbutamol in the baseline period, with 15.7% receiving salbutamol after the intervention period (Dowling et al., 2020). These studies provide evidence that audit-feedback tools may be beneficial in increasing adherence to the AAP bronchiolitis guidelines in regards to bronchodilator therapy.

Alternatively, Dunn et al., (2020) aimed to reduce the proportion of ED patients with bronchiolitis who received bronchodilators. This was completed through changes in the bronchiolitis pathway and associated education on the changes made. The researchers assembled a multidisciplinary team that reviewed a process map and discussed potential drivers of unnecessary albuterol use. The team then updated the existing bronchiolitis clinical pathway and provided didactic education to physicians, nurses, and respiratory therapists. They also included an opt-in albuterol trial in the bronchiolitis order set that provided clinical decision support that encouraged providers against the use of bronchodilators. To determine the impact of these interventions, a study was performed that included all patients with a discharge diagnosis of acute bronchiolitis aged 29 days to one year seen from October 2014 to March 2017 for a total of 3,834 ED encounters and 1,119 inpatient encounters. Results showed that the proportion of infants who received bronchodilators in the ED in the pre-intervention period was 43%, in the intervention period was 22%, and in the post-intervention period was 20%. In the inpatient

setting, 18% of infants received bronchodilators in the pre-intervention period, 13% in the intervention period, and 11% in the post-intervention period (Dunn et al., 2020). A similar study performed by Feder et al., (2019) examined the effect of a preprinted order (PPO) set based on the current clinical guidelines on the LOS and resource utilization on children admitted to the hospital with a diagnosis of bronchiolitis. This was performed via a retrospective chart review that included a total of 245 patients (122 from the pre-intervention period and 123 from the post-intervention period). Analysis showed that in the pre-intervention period 31.3% of patients received salbutamol nebulizers, while only 14.6% received salbutamol nebulizers in the port-intervention period (p-value = 0.002). Together, these studies provide evidence that bronchiolitis pathways and preprinted order sets may decrease the use of bronchodilators for bronchiolitis.

A final study performed by Molloy et al., (2019) implemented an educational intervention to help improve adherence to the AAP bronchiolitis guidelines. Researchers included 321 children (136 pre-intervention and 185 post-intervention) aged one month to 23 months with a diagnosis of bronchiolitis or RSV seen between 2015 to 2017. The intervention was implemented during the 2016-2017 bronchiolitis season and included EMR standardized documentation phrases that highlighted the current guidelines, and informational emails that were sent every two weeks. Additionally, handouts with bronchiolitis information were printed and posted near workstations and workrooms. Outcomes showed that in the pre-intervention period a total of 62.5% of patients received bronchodilators compared with 22.7% who received bronchodilators post-intervention ($P < .001$). This study provides evidence that educational interventions may have a significant impact on the reduction of bronchodilator use for bronchiolitis.

Study Limitations and Gaps in Literature

To properly evaluate findings and the need for future research, it is essential to discuss any limitations and gaps in the literature reviewed. One of the main limitations of the reviewed studies is their reliance on administrative data, which may contain recording errors. Furthermore, missing data in respect to retrospective data collection has the potential for information bias. In addition, a variation in the clinical definition of bronchiolitis exists, which could have an impact on the selection of patients and population size. Furthermore, there are many diagnosis codes for bronchiolitis and RSV, which may include codes for viral related wheezing. Differing diagnosis codes may also impact the selection of patients.

The study performed by Cai et al., (2020) relied on administrative data, and authors noted that characteristic data was unable to be obtained from the original studies. Additionally, many of the articles originally reviewed were eliminated due to insufficient data, which may have led to some bias. Dowling et al., (2020), performed a large study, however, a higher proportion of cases were admitted in the intervention period as compared to the pre-intervention period, which could be due to bronchiolitis severity seen in different seasons. Dunn et al., (2020) and Lawerence et al., (2023) implemented multiple interventions at the same time, making it difficult to decipher which intervention, or the combined interventions, had the biggest impact on results. In the study conducted by Haung et al., (2024), authors included diagnosis of pneumonia and wheezing, as distinguishing these from bronchiolitis in this age-group is difficult. While authors did conduct a sensitivity analysis to exclude asthma, there is potential that some patients with asthma were included in the study. Finally, the studies performed by Pinto et al., (2016) and Spindler et al., (2023) evaluated data from single settings, which may not reflect the findings on a larger scale.

While the review of the available literature provided many significant findings regarding various aspects of the use of bronchodilators as a management for bronchiolitis, it also uncovered gaps in the literature that demand more research. Since the release of the AAP guidelines in 2014, few studies have focused on the outcomes associated with early use of bronchodilators. Some have proposed that the use of these medications may lead to patient harm and increased need for oxygen therapy, while others postulate that since the COVID-19 pandemic, a change in viral bronchiolitis has occurred, in which bronchodilators are more effective. Additionally, new theories suggest that various phenotypes are associated with bronchiolitis, however little research has been done to provide evidence for these phenotypes. Future studies should focus on physical outcomes that may be associated with bronchodilator therapy, determine any changes in bronchiolitis since the COVID-19 pandemic, and investigate the potential of various phenotype subgroups in those with bronchiolitis.

Summary

The review of current literature focused on examining the current use of bronchodilators in the management of bronchiolitis, the efficacy and outcomes associated with the use of bronchodilators in bronchiolitis, and the impact of various interventions on decreasing the use of bronchodilators in those with bronchiolitis. 15 research studies, including three retrospective cross-sectional studies, five retrospective cohort studies, one meta-analysis, and one retrospective case control study were included in this review. The studies reviewed highlighted the varying role, and effectiveness, that bronchodilators may have in the treatment of bronchiolitis. While current AAP guidelines recommend against the routine use of bronchodilators in the management of bronchiolitis, the use of these medications remains varied in practice (Hester et al., 2019; House et al., 2021). Furthermore, no significant change in patient

outcomes, such as length of stay or admission to the hospital, is seen when the early use of bronchodilators is decreased (Pinto et al., 2016; Shanahan et al., 2021). Similarly, when researching the outcomes and efficacy of bronchodilators in bronchiolitis management, it has been found that there are no significant improvements in outcomes when using bronchodilators, and instead these medications may lead to patient harm when used in the setting of bronchiolitis (Cai et al., 2020; Shanahan et al., 2021). Finally, this review investigated various interventions that may have an impact on decreasing the use of bronchodilators in the management of bronchiolitis. Interventions may include education, audit-feedback tools, EMR alerts, PPO sets, and the implementation of bronchiolitis pathways (Dowling et al., 2020; Dunn et al., 2020; Feder et al., 2019; Lawrence et al., 2023; Molloy et al., 2019). In conjunction, these studies show the current inconsistency in management of bronchiolitis with bronchodilators and indicate the need for new research to determine if a change in guidelines is warranted. As such, hospital systems throughout the United States should work towards the implementation of consistent routine treatment of bronchiolitis in infants and should consider interventions to decrease the use of these therapies.

In conclusion, bronchiolitis is a significant public health concern, affecting an estimated 34 million children under the age of two annually (WHO, 2017). Current AAP guidelines recommend against the routine use of bronchodilators in the management of bronchiolitis; however, many providers use a varied approach in its use. To better understand bronchodilators efficacy and effect on patient outcomes, as well as the changes in bronchiolitis since the COVID-19 pandemic, further research is needed.

Appendix 1

Tool 2.1 PICO Concepts for Developing a Purpose Statement

INSTRUCTIONS: Use this worksheet to explore concepts of interest for your EBP work. Organize using the PICO elements. Begin by identifying a goal or outcome first. Identify potential interventions last; interventions may evolve after reading the evidence. Use all PICO elements to write a purpose statement in one to two sentences. Use PICO elements to identify potential keywords related to the purpose statement.

Patient Population

Pediatric patients aged two years or younger with a diagnosis of bronchiolitis or respiratory syncytial virus (RSV) that have been seen in a primary care office, urgent care, emergency department, or hospitalized.

Clinical Problem or Condition

Current treatment guidelines recommend against the use of bronchodilators for bronchiolitis, however a varied approach to their use remains.

Pilot Area

Riley Hospital for Children

Interventions

The use of bronchodilators, such as albuterol (also known as salbutamol), for the management of bronchiolitis or RSV in the pediatric population.

Comparison

The use of supportive care without the use of bronchodilators for the management of bronchiolitis or RSV in the pediatric population.

Anticipated Outcomes

I anticipate that recent research will show that bronchodilators continue to be overused in those with bronchiolitis.

EBP Purpose Statement

The purpose of this integrative review is to further investigate the current use of bronchodilators in the management of bronchiolitis, as well as their associated outcomes. We will determine current recommendations for the use of bronchodilators in bronchiolitis, the health outcomes associated with or without the use of bronchodilators and evaluate various interventions that may be used to decrease their use.

Keywords or Concepts for Identifying and Organizing Literature

Bronchiolitis, respiratory syncytial virus, bronchodilators, albuterol, salbutamol, treatment, management, guidelines, protocol, phenotype

Tool 2.2 PICO Elements for a Purpose Statement and Evidence Search

INSTRUCTIONS: Use this worksheet to develop a purpose statement or question. Describe each PICO element addressing the topic of interest. Identify the outcome before considering interventions; interventions may evolve after reading the evidence. Write a purpose statement and determine the kind of question. Use Table 2.1 to identify study designs most likely to answer this question. List related concepts, inclusion and exclusion criteria, and keywords or concepts for organizing evidence.

Step 1: Define elements or clinical question using PICO:

P = Patients or population to target: Pediatric patients under the age of two with a diagnosis of bronchiolitis or RSV that have been seen in a primary care office, urgent care, emergency department, or hospitalized in the last five years.

Problem or condition to address: Use of bronchodilators for the treatment of bronchiolitis

Pilot area (e.g., unit/clinic): Riley Hospital for Children

I = Intervention (assessment or treatment): The use of bronchodilators for the management of bronchiolitis in the pediatric population.

C = Comparison: The use of supportive care without the use of bronchodilators for the management of bronchiolitis in the pediatric population.

O = Outcomes: I anticipate that recent research will indicate that bronchodilators still remain overused in the management of bronchiolitis

T = Time frame (optional): Research articles will be included if published within the last ten years.

Step 2: Purpose statement:

The purpose of this integrative review is to further investigate the current use of bronchodilators in the management of bronchiolitis, as well as their associated outcomes. We will determine current recommendations for the use of bronchodilators in bronchiolitis, the health outcomes associated with or without the use of bronchodilators and evaluate various interventions that may be used to decrease their use.

Step 3: Determine what your question is about (circle one):

(Therapy) Diagnosis Etiology Prognosis Meaning

Step 4: Identify study types that best address your question (circle one or more):

(Experimental studies)	Observational studies	(Qualitative studies)
(Systematic review or meta-analysis)	Case reports	Other

Step 5: List the main terms and synonyms for your purpose statement. Typical number of concepts per question is two to three.

Concept 1: Bronchiolitis	Concept 2: Bronchodilators	Concept 3: Management
Bronchiolitis, Respiratory syncytial virus	Albuterol, salbutamol	Treatment, protocol, guidelines

Step 6: List inclusion and exclusion criteria:

Inclusion Criteria: Patients aged 2 years and less with a diagnosis of bronchiolitis or respiratory syncytial virus seen in a primary care office, urgent care, emergency department, or admitted for hospitalization. Research articles obtained will be from the previous ten years.

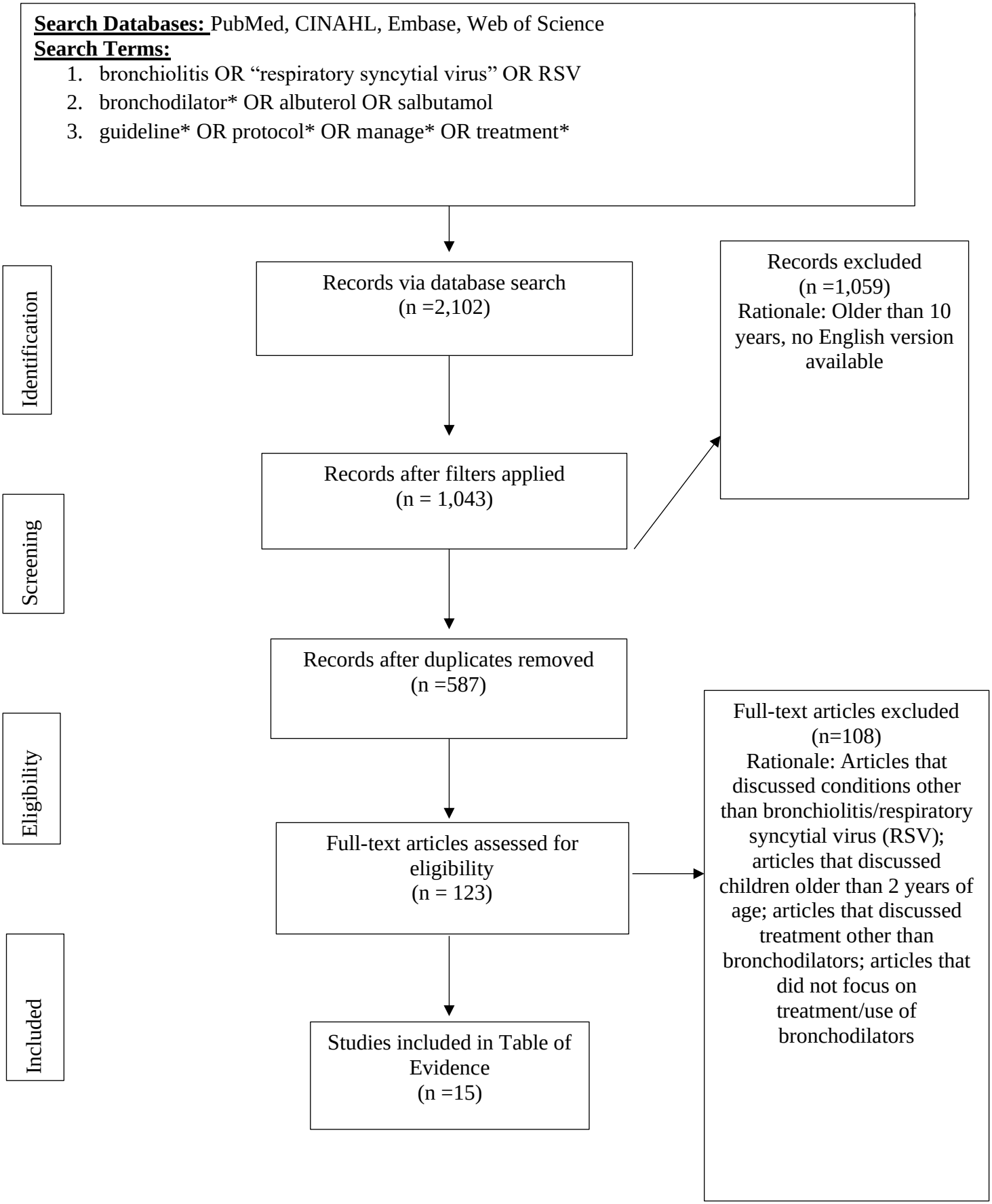
Step 7: Keywords or concepts for organizing literature:

Bronchiolitis, respiratory syncytial virus, bronchodilators, albuterol, salbutamol, treatment, guidelines, protocol, phenotypes

Tool 5.2 Record of Search History and Yield by Source

INSTRUCTIONS: When using bibliographic databases, save the search history. Include the terms used, how terms were combined, and the yield from each search.

Database	Search or MeSH Term (List)	Approaches for Combining Terms (Boolean Operators) AND/OR/NOT	Limits Used	Yield (Combined Keywords and Numbers of Articles Identified)
Web of Science: Scholarly articles from social science and scientific journals, and provides cited reference tracking and journal impact factors. https://clarivate.com/products/scientific-and-academic-research/research-discovery-and-workflow-solutions/webofscience-platform/	bronchiolitis, respiratory syncytial virus, RSV, bronchodilator, albuterol, salbutamol, guideline, protocol, management, treatment	AND/OR	Previous 10 years	275
Embase: Embase is the medical research database for high-quality, comprehensive evidence https://www.embase.com/landing?status=grey	bronchiolitis, respiratory syncytial virus, RSV, bronchodilator, albuterol, salbutamol, guideline, protocol, management, treatment	AND/OR	Previous 10 years	390
PubMed: PubMed is composed of more than 26 million citations for biomedical literature from MEDLINE, life science journals, and online books. www.ncbi.nlm.nih.gov/pubmed	bronchiolitis, respiratory syncytial virus, RSV, bronchodilator, albuterol, salbutamol, guideline, protocol, management, treatment	AND/OR	Previous 10 years	268
CINAHL: CINAHL Plus with full text indexes over 5,000 journals from the fields of nursing and allied health, with indexing back to 1937. https://health.ebsco.com/products/cinahl-plus-with-full-text	bronchiolitis, respiratory syncytial virus, RSV, bronchodilator, albuterol, salbutamol, guideline, protocol, management, treatment	AND/OR	Previous 10 years	110


Search Databases: PubMed, CINAHL, Embase, Web of Science
Search Terms:
1. bronchiolitis OR "respiratory syncytial virus" OR RSV
2. bronchodilator* OR albuterol OR salbutamol
3. guideline* OR protocol* OR manage* OR treatment*
Identification
Records via database search (n =2,102)
Records excluded (n =1,059) Rationale: Older than 10 years, no English version available
Screening
Records after filters applied (n = 1,043)
Records after duplicates removed (n =587)
Eligibility
Full-text articles assessed for eligibility (n = 123)
Full-text articles excluded (n=108) Rationale: Articles that discussed conditions other than bronchiolitis/respiratory syncytial virus (RSV); articles that discussed children older than 2 years of age; articles that discussed treatment other than bronchodilators; articles that did not focus on treatment/use of bronchodilators
Included
Studies included in Table of Evidence (n =15)

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Appendix 2

Reference:

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Category of study designs	Methodological quality criteria Responses	Responses			
		Yes	No	Can't tell	Comments
Screening questions (for all types)	S1. Are there clear research questions?	X			
	S2. Do the collected data allow to address the research questions?	X			
	Further appraisal may not be feasible or appropriate when the answer is 'No' or 'Can't tell' to one or both screening questions.				
1. Qualitative	1.1. Is the qualitative approach appropriate to answer the research question?				
	1.2. Are the qualitative data collection methods adequate to address the research question?				
	1.3. Are the findings adequately derived from the data?				
	1.4. Is the interpretation of results sufficiently substantiated by data?				
	1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?				
2. Quantitative randomized controlled trials	2.1. Is randomization appropriately performed?	X			
	2.2. Are the groups comparable at baseline?	X			
	2.3. Are there complete outcome data?		X		
	2.4. Are outcome assessors blinded to the intervention provided?			X	
	2.5 Did the participants adhere to the assigned intervention?	X			
3. Quantitative non randomized	3.1. Are the participants representative of the target population?				
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?				
	3.3. Are there complete outcome data?				
	3.4. Are the confounders accounted for in the design and analysis?				
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?				
4. Quantitative descriptive	4.1. Is the sampling strategy relevant to address the research question?				
	4.2. Is the sample representative of the target population?				
	4.3. Are the measurements appropriate?				
	4.4. Is the risk of nonresponse bias low?				
	4.5. Is the statistical analysis appropriate to answer the research question?				
5. Mixed methods	5.1. Is there an adequate rationale for using a mixed methods design to address the research question?				
	5.2. Are the different components of the study effectively integrated to answer the research question?				
	5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted?				
	5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?				
	5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?				

Reference:

Dowling SK, Gjata I, Solbak NM, Weaver CGW, Smart K, Buna R, & Stang AS. (2020). Group-facilitated audit and feedback to improve bronchiolitis care in the emergency department. *CJEM*, *22*(5), 678–686. https://doi.org/10.1017/cem.2020.374

Category of study designs	Methodological quality criteria Responses	Responses			
		Yes	No	Can't tell	Comments
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	S2. Do the collected data allow to address the research questions?	X			
	Further appraisal may not be feasible or appropriate when the answer is 'No' or 'Can't tell' to one or both screening questions.				
1. Qualitative	1.1. Is the qualitative approach appropriate to answer the research question?				
	1.2. Are the qualitative data collection methods adequate to address the research question?				
	1.3. Are the findings adequately derived from the data?				
	1.4. Is the interpretation of results sufficiently substantiated by data?				
	1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?				
2. Quantitative randomized controlled trials	2.1. Is randomization appropriately performed?				
	2.2. Are the groups comparable at baseline?				
	2.3. Are there complete outcome data?				
	2.4. Are outcome assessors blinded to the intervention provided?				
	2.5 Did the participants adhere to the assigned intervention?				
3. Quantitative non randomized	3.1. Are the participants representative of the target population?	X			
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
4. Quantitative descriptive	4.1. Is the sampling strategy relevant to address the research question?				
	4.2. Is the sample representative of the target population?				
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	4.4. Is the risk of nonresponse bias low?				
	4.5. Is the statistical analysis appropriate to answer the research question?				
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	5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?				

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Category of study designs	Methodological quality criteria Responses	Responses			
		Yes	No	Can't tell	Comments
Screening questions (for all types)	S1. Are there clear research questions?	X			
	S2. Do the collected data allow to address the research questions?	X			
	Further appraisal may not be feasible or appropriate when the answer is 'No' or 'Can't tell' to one or both screening questions.				
1. Qualitative	1.1. Is the qualitative approach appropriate to answer the research question?				
	1.2. Are the qualitative data collection methods adequate to address the research question?				
	1.3. Are the findings adequately derived from the data?				
	1.4. Is the interpretation of results sufficiently substantiated by data?				
	1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?				
2. Quantitative randomized controlled trials	2.1. Is randomization appropriately performed?				
	2.2. Are the groups comparable at baseline?				
	2.3. Are there complete outcome data?				
	2.4. Are outcome assessors blinded to the intervention provided?				
	2.5 Did the participants adhere to the assigned intervention?				
3. Quantitative non randomized	3.1. Are the participants representative of the target population?	X			
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?			X	
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
4. Quantitative descriptive	4.1. Is the sampling strategy relevant to address the research question?				
	4.2. Is the sample representative of the target population?				
	4.3. Are the measurements appropriate?				
	4.4. Is the risk of nonresponse bias low?				
	4.5. Is the statistical analysis appropriate to answer the research question?				
5. Mixed methods	5.1. Is there an adequate rationale for using a mixed methods design to address the research question?				
	5.2. Are the different components of the study effectively integrated to answer the research question?				
	5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted?				
	5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?				
	5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?				

Reference:

Feder J, Bijelic V, Barrowman N, McDonald J, Murchison B, Jetty R, Tjahjadi A, Parker K, Pothos M, & Pound CM. (2019). The impact of implementing a preprinted order form for inpatient management of otherwise healthy children admitted to a tertiary care centre with a diagnosis of bronchiolitis. *Paediatric Child Health*, *24*(8), 495–501. https://doi.org/10.1093/pch/pxy191

Category of study designs	Methodological quality criteria Responses	Responses			
		Yes	No	Can't tell	Comments
Screening questions (for all types)	S1. Are there clear research questions?	X			
	S2. Do the collected data allow to address the research questions?	X			
	Further appraisal may not be feasible or appropriate when the answer is 'No' or 'Can't tell' to one or both screening questions.				
1. Qualitative	1.1. Is the qualitative approach appropriate to answer the research question?				
	1.2. Are the qualitative data collection methods adequate to address the research question?				
	1.3. Are the findings adequately derived from the data?				
	1.4. Is the interpretation of results sufficiently substantiated by data?				
	1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?				
2. Quantitative randomized controlled trials	2.1. Is randomization appropriately performed?				
	2.2. Are the groups comparable at baseline?				
	2.3. Are there complete outcome data?				
	2.4. Are outcome assessors blinded to the intervention provided?				
	2.5 Did the participants adhere to the assigned intervention?				
3. Quantitative non randomized	3.1. Are the participants representative of the target population?	X			
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
4. Quantitative descriptive	4.1. Is the sampling strategy relevant to address the research question?				
	4.2. Is the sample representative of the target population?				
	4.3. Are the measurements appropriate?				
	4.4. Is the risk of nonresponse bias low?				
	4.5. Is the statistical analysis appropriate to answer the research question?				
5. Mixed methods	5.1. Is there an adequate rationale for using a mixed methods design to address the research question?				
	5.2. Are the different components of the study effectively integrated to answer the research question?				
	5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted?				
	5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?				
	5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?				

Reference:

Gong C, Byczkowski T, McAneney C, Goyal MK, & Florin TA. (2019). Emergency department management of bronchiolitis in the United States. *Pediatric Emergency Care*, *35*(5), 323–329. https://doi.org/10.1097/PEC.0000000000001145

Category of study designs	Methodological quality criteria Responses	Responses			
		Yes	No	Can't tell	Comments
Screening questions (for all types)	S1. Are there clear research questions?	X			
	S2. Do the collected data allow to address the research questions?	X			
	Further appraisal may not be feasible or appropriate when the answer is 'No' or 'Can't tell' to one or both screening questions.				
1. Qualitative	1.1. Is the qualitative approach appropriate to answer the research question?				
	1.2. Are the qualitative data collection methods adequate to address the research question?				
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	2.5 Did the participants adhere to the assigned intervention?				
3. Quantitative non randomized	3.1. Are the participants representative of the target population?	X			
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
4. Quantitative descriptive	4.1. Is the sampling strategy relevant to address the research question?				
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Reference:

Hester G, Nickel AJ, Watson D, & Bergmann KR. (2021). Factors associated with bronchiolitis guideline nonadherence at US children's hospitals. *Hospital Pediatrics*, *11*(10), 1102–1112. https://doi.org/10.1542/hpeds.2020-005785

Category of study designs	Methodological quality criteria Responses	Responses			
		Yes	No	Can't tell	Comments
Screening questions (for all types)	S1. Are there clear research questions?	X			
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	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?			X	
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
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Reference:

House SA, Marin JR, Hall M, & Ralston SL. (2021). Trends over time in use of nonrecommended tests and treatments since publication of the American Academy of Pediatrics Bronchiolitis Guideline. *JAMA Network Open*, *4*(2), e2037356. https://doi.org/10.1001/jamanetworkopen.2020.37356

Category of study designs	Methodological quality criteria Responses	Responses			
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Screening questions (for all types)	S1. Are there clear research questions?	X			
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Reference:

Huang, J., Moss, A., Hoyt, B. M., Watson, J. D., & Brittan, M. S. (2024). Factors associated with inhaled bronchodilator and oral corticosteroid use in young children with first lower respiratory tract infection. *The Journal of Pediatrics, 267*. https://doi.org/10.1016/j.jpeds.2024.113912

Category of study designs	Methodological quality criteria Responses	Responses			
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Screening questions (for all types)	S1. Are there clear research questions?	X			
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Reference:

Lawrence J, Hiscock H, Voskoboynik A, Walpola R, & Sharma A. (2023). Impact of an intervention to reduce bronchodilator use in bronchiolitis—A time series analysis. *Hospital Pediatrics*, *13*(8), 653–659. https://doi.org/10.1542/hpeds.2022-007059

Category of study designs	Methodological quality criteria Responses	Responses			
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Screening questions (for all types)	S1. Are there clear research questions?	X			
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Reference:

Maki K, Azizi H, Hans P, & Doan Q. (2021). Adherence to national paediatric bronchiolitis management guidelines and impact on emergency department resource utilization. *Paediatric Child Health*, *26*(2), 108–113. https://doi.org/10.1093/pch/pxaa013

Category of study designs	Methodological quality criteria Responses	Responses			
		Yes	No	Can't tell	Comments
Screening questions (for all types)	S1. Are there clear research questions?	X			
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Reference:

Molloy MJ, Tamaroff J, McDaniel L, & Genies MC. (2019). Targeted education across clinical settings improves adherence to evidence-based interventions for bronchiolitis. *Clinical Pediatrics*, *58*(11–12), 1284–1290. https://doi.org/10.1177/0009922819852982

Category of study designs	Methodological quality criteria Responses	Responses			
		Yes	No	Can't tell	Comments
Screening questions (for all types)	S1. Are there clear research questions?	X			
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Reference:

Pinto JM, Schairer JL, & Petrova A. (2016). Duration of hospitalization in association with type of inhalation therapy used in the management of children with nonsevere, acute bronchiolitis. *Pediatric Neonatology*, *57*(2), 140–144. https://doi.org/10.1016/j.pedneo.2015.04.014

Category of study designs	Methodological quality criteria Responses	Responses			
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Screening questions (for all types)	S1. Are there clear research questions?	X			
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Reference:

Rivera-Sepulveda AV, Rebmann T, Gerard J, & Charney RL. (2019). Physician compliance with bronchiolitis guidelines in pediatric emergency departments. *Clinical Pediatrics*, *58*(9), 1008–1018. https://doi.org/10.1177/0009922819850462

Category of study designs	Methodological quality criteria Responses	Responses			
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Screening questions (for all types)	S1. Are there clear research questions?	X			
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References:

Shanahan, K. H., Monuteaux, M. C., Nagler, J., & Bachur, R. G. (2021). Early use of bronchodilators and outcomes in bronchiolitis. *Pediatrics*, *148*(2), e2020040394. https://doi.org/10.1542/peds.2020-040394

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		Yes	No	Can't tell	Comments
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Reference:

Spindler D, Monroe KK, Malakh M, McCaffery H, Shaw R, Biary N, Foo K, Levy K, Vittorino R, Desai P, Schmidt J, Saul D, Skoczylas M, Chang YK, Osborn R, & Jacobson E. (2023). Management practices for standard-risk and high-risk patients with bronchiolitis. *Hospital Pediatrics*, *13*(9), 833–840. https://doi.org/10.1542/hpeds.2022-006518

Category of study designs	Methodological quality criteria Responses	Responses			
		Yes	No	Can't tell	Comments
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	4.3. Are the measurements appropriate?				
	4.4. Is the risk of nonresponse bias low?				
	4.5. Is the statistical analysis appropriate to answer the research question?				
5. Mixed methods	5.1. Is there an adequate rationale for using a mixed methods design to address the research question?				
	5.2. Are the different components of the study effectively integrated to answer the research question?				
	5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted?				
	5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?				
	5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?				

Table of Evidence

Synthesis of Evidence for "Use of Bronchodilators in Bronchiolitis"

Reference, Year	**Study Design**	**Population, Setting, n**	**Study Objectives**	**Study Results**	**Comments**
(Cai et al., 2020)	Systemic review and meta-analysis of randomized control trials STATA was used to extract and analyze data	Study of 13 randomized control trials that included 977 participants less that 24 months of age with acute bronchiolitis	To utilize a systematic randomized review to evaluate the efficacy of the use of salbutamol in the treatment of infants with bronchiolitis	An increase in heart and respiratory rate was found in infants treated with salbutamol Oxygen saturation, clinical severity score, or length of hospital stay between groups was not statistically significant	This study investigated the effects of salbutamol on heart rate, respiratory rate, oxygen saturation, clinical severity score, and hospital length of stay in patients treated with the bronchodilator salbutamol. Authors mention the theoretical effect of salbutamol on acute bronchiolitis, however given the side effects and lack of benefits recommend against the use of the medication for bronchiolitis
(Dowling et al., 2020)	Interventional study	This studied included 47 providers and 3,883 patients aged 12 months and younger who had a diagnosis of bronchiolitis at the time of the encounter	To determine the outcomes associated with group-facilitated audits for providers on their management practices of bronchiolitis	Data analysis revealed that for participants not admitted to the hospital 17.9% were administered salbutamol in the baseline period with 10.8% receiving it during the intervention period	This study focuses on the use of group-facilitated audits to decrease bronchodilator use in those with bronchiolitis. This study encompassed a large setting (seven EDs) and a decrease in bronchodilator prescription was observed after the intervention

		Study included seven emergency departments (ED) Encounters were excluded if they occurred out-of-season (May 1-October 31)		Additionally, of those admitted to the hospital, 21.1% were administered salbutamol during the baseline period compared to 15.7% during the intervention period	
(Dunn et al., 2020)	Quasi-experimental design	The study consisted of 3,834 emergency department visits and 1,119 inpatient hospitalizations from October 2014 to March 2017 All patients studied were between the ages of 29 days and one year with a discharge diagnosis of bronchiolitis	To determine the efficacy of provider education and the implementation of clinical pathways on decreasing bronchodilator use in the management of bronchiolitis	Infants treated with albuterol in the emergency room experienced a decrease in the use of bronchodilators from the pre-intervention to post-intervention period (from 43% pre-intervention to 20% post-intervention) Infants treated with albuterol in the inpatient setting experienced a decrease in the use of bronchodilators from the pre-intervention to post-intervention period (from 18% pre-intervention to 11% post-intervention)	Authors discuss the use of a multidisciplinary team to create an updated clinical pathway leading to a reduction in the number of bronchodilators ordered for bronchiolitis
(Feder et al., 2019)	Retrospective chart review	This study included a total of 245 pediatric patients (122 pre-intervention and 123	To examine the impact of a preprinted order set (PPO) on	From pre-intervention to post-intervention a decrease in the LOS from 3.1 to 2.8 days, decrease in	Researchers worked to understand the impact of a PPO on resource utilization in infants with bronchiolitis.

		post-intervention) admitted to the Children's Hospital of Eastern Ontario with a diagnosis of bronchiolitis between December 1, 2014, to June 30, 2016 Patients with a history of congenital heart disease requiring medical therapy, chronic lung disease, genetic conditions, or with neurological impairments were excluded	the length of stay (LOS) and resource utilization for children with bronchiolitis	salbutamol nebulizers from 38% to 18%, and a decrease in salbutamol metered dose inhalers from 28% to 16% was seen	It was determined that with a PPO both LOS and the administration of bronchodilators decreased
(Gong, et al., 2019)	Cross sectional study Data was pulled from the National Hospital Ambulatory Medical Care Survey	A total of 751 children younger than 24 months seen in a pediatric or general hospital emergency room with a diagnosis of bronchiolitis between the years of 2002 and 2011 were included in the study Authors used weighted frequency distribution to determine an	Comparison of bronchiolitis management strategies between pediatric and general hospital emergency departments (ED)	Authors found that more pediatric patients are treated for bronchiolitis in general EDs compared to pediatric EDs, however the use of bronchodilators was more common in pediatric emergency rooms (weighted percentages showed 69% in pediatric EDs vs 48.6 % in general EDs)	This study investigated bronchodilator use for the management of bronchiolitis in general EDs compared to pediatric EDs. It was determined general EDs prescribe bronchodilators less than pediatric EDs. Authors used a weighted distribution frequency

		estimated weighted number of visits of 2,550,000			
(Hester et al., 2019)	Retrospective administrative database study Data was collected from the Pediatric Health Information System database which includes encounters at 52 children's hospitals across the United States	A total of 198,028 patients aged 1 month to 2 years seen in an emergency department (ED) or admitted with a bronchiolitis diagnosis were included Children were included if they were seen between January 1, 2016, to December 31, 2018 Participants were excluded if their encounter included an intensive care stay, if they had a concurrent diagnosis of croup, pneumonia, or asthma, or if they had any complex medical conditions defined by Feudtner's classification and/or the Pediatric Medical Complexity Algorithm	Authors investigated factors associated with nonadherence to the national bronchiolitis guidelines	Analysis showed that 19.3% of ED encounters and 32.7% of inpatient encounters were non-adherent with current guidelines regarding bronchodilator use in the management of bronchiolitis Additionally, it was determined that Non-Hispanic Black patients, older patients and those seen for a secondary encounter were more likely to be prescribed bronchodilators, while American Indians were less likely to receive therapy The study also revealed that Pediatricians, nurse practitioners and physician's assistants were less likely to order bronchodilators than pediatric emergency medicine physicians	The focus of this study was on provider nonadherence to bronchiolitis guidelines, including the use of bronchodilators. Researchers found that participants with inpatient encounters were more likely to receive bronchodilators than those seen in an ED

(House et al., 2021)	Retrospective, observational hospital cohort study Data was obtained from the Pediatric Health Information Systems database	The patient population included 602,375 children aged 28 days to 2 years discharged between November 1, 2006, to December 31, 2019 with a discharge diagnosis of acute bronchiolitis	Evaluated trends in bronchiolitis management since the original publication and update of the American Academy of Pediatrics clinical practice guidelines on bronchiolitis	Since the original publication in 2006 to the publication of updated guidelines in 2014, bronchodilator use decreased by 13.5% in emergency departments (ED) and 11.3% in inpatient settings After the publication of the updated guidelines in 2014, the ED negative monthly trajectory steepened from -0.11% to -0.26% and the inpatient group improved from -0.08% to -0.26%	This article represents a large study evaluating trends in bronchiolitis management from 2006-2019. It provides evidence that a decrease in bronchodilator use since the development of the national bronchiolitis guidelines and the publication of the update has occurred
(Huang et al., 2024)	Retrospective cohort study Data was sourced from the Colorado All Payer Claims Database	The cohort included 10,194 pediatric patients less than two years old with at least one lower respiratory tract infection (LRTI), such as bronchiolitis or pneumonia, or wheezing related visit between 2015 to 2019 Children with a previous or concurrent diagnosis of asthma were excluded	Evaluation of factors associated with the use of bronchodilators in patients with LRTI	Of the study participants, 14.4% had a bronchodilator claim at or within seven days of diagnosis Bronchodilator prescriptions were associated with male sex, older age, non-inpatient settings, atopy, public insurance and prior bronchodilator or steroid claims. No association with a history of complex chronic conditions or	This study evaluated factors associated with bronchodilator use in patients with LRTI. Patients included diagnoses of pneumonia and wheeze, as well as bronchiolitis, given the challenge in clinically distinguishing these diagnoses in the pediatric population

				asthma family history was found	
(Lawrence et al., 2023)	Quality improvement study using an interrupted time series analysis and poisson regression analysis Analyses conducted using STATA software	Infants aged one to 12 months with a diagnosis of bronchiolitis seen in an emergency department (ED) of a large pediatric teaching hospital between May 1, 2016, and August 31, 2022. Infants were excluded if they were admitted to an intensive care unit A total of 9,576 infants were included in the study (4,635 infants' pre-intervention and 4,948 post-intervention)	Assessment of the impact of a multifaceted intervention (education, clinician audit-audit feedback, and electronic medical record (EMR) alert on rates of bronchodilator use for treatment of patients with bronchiolitis to determine monthly count data for bronchodilator orders and impact of the intervention over time	It was determined that males, older infants, and infants admitted to the pediatric ward received bronchodilators more frequently A decrease in bronchodilator orders from 6.9% pre-intervention to 3.2% post-intervention was seen The EMR alert was activated for 200 unique patients. Of the patients in which the EMR alert was activated 180 (90%) ultimately were prescribed bronchodilators. Provider reasons for overriding the alert included: patients close to 12 months old, a family history of asthma, and a previous response to bronchodilators	Authors investigated the results of provider education, clinician audit-audit feedback, and an EMR alert on the prescription of bronchodilators. After the intervention a decrease in the rate of bronchodilator prescription was found
(Maki et al., 2021)	Retrospective case control study	Participants included 185 infants less than 12 months old who presented to the BC Children's Hospital Emergency Department (PED) between December 1, 2014, and April 24,	Investigation of the association between the use of salbutamol and corticosteroids on frequency of return visits and length of stay (LOS) in the	Of the 185 participants, it was determined that 64 received salbutamol in the PED and 50 were instructed to continue the medication after discharge. Additionally, salbutamol use was associated with a mean	The purpose of this study was to investigate the association between non-recommended pharmacology (salbutamol) on LOS in a PED. Authors found that those that received salbutamol in the PED had an increased LOS

		2017 and discharged home with a diagnosis of bronchiolitis Infants were included if they had one or more viral prodrome symptom and one or more physical exam findings of respiratory distress	pediatric emergency department	58.3-minute increase in PED LOS	
(Molloy et al., 2019**)**	Pre-post intervention study	Study population included a total of 321 participants (136 pre-intervention and 185 post-intervention) aged one month to 23 months with a diagnosis of bronchiolitis or respiratory syncytial virus treated in the emergency department of a large urban academic children's center	Determine effects of an educational intervention and the creation of a standardized electronic medical record (EMR) phrase reinforcing the clinical practice guidelines on the use of bronchodilators in the management of bronchiolitis	In the emergency department (ED) 62.5% received bronchodilators prior to the intervention, while only 22.7% received them post-intervention Less significantly 22.2% received bronchodilators pre-intervention with 17.8% receiving them post-intervention in the inpatient center	To decrease nonadherence to national bronchiolitis guidelines, authors created an educational intervention that was used in combination with a standardized EMR phrase to lower rates of bronchodilator prescription. The intervention led to a decrease in rates of bronchodilator orders in both the ED and inpatients settings, however a more significant difference was noted in the ED
(Pinto et el., 2016)	Retrospective review of medical records	Authors included 195 participants aged two years or less, born at term gestation, without chronic conditions	Evaluate the association between different types of nebulized therapies (albuterol, albuterol	It was determined that 27.2% of participants received albuterol alone	This study's results substantiate the premise that clinical outcomes such a LOS are not significantly

		(lung disease, asthma, immunodeficiency, congenital heart disease, or cystic fibrosis) and without evidence of chest radiography-confirmed pneumonia and/or admission to the pediatric intensive care unit seen at Jersey Shore University Medical Center	in combination with 3% saline, nebulized 3% saline alone, and no inhaled therapy) in clinical practice and length of stay (LOS) of children with bronchiolitis	Albuterol was administered more frequently in those with higher respiratory scores No significant difference in LOS between patients who were treated with bronchodilators compared with those who received no therapies	associated with the use of bronchodilators
(Rivera-Sepulveda et al., 2019)	Cross-sectional survey	Study included 214 providers in the practice of pediatric emergency medicine from the AAP Section on Emergency Medicine in the fall of 2017	Evaluation of provider knowledge, agreement, and compliance with the American Academy of Pediatrics guidelines, attitudes and beliefs, perceived barriers and perceived usefulness regarding the use of bronchodilators for management of bronchiolitis.	97.7% of providers reported knowledge of current guidelines Regarding use of bronchodilators 8.9% of providers reported never having used them, 43% reported rarely using them, 40.7% reported sometimes using them, and 7.4% reported using them most of the time or always Providers who agreed with the science behind the guidelines were more likely to be compliant	This study evaluated pediatric emergency department physicians' utilization of accepted guidelines specific to the treatment of bronchiolitis. The results indicated that there is a significant difference among participants in their management of the disease based upon the guidelines. Authors indicated concerns related to the accuracy of data collection, extrapolation of actual bronchodilator usage, diagnosis, treatment and treatment methodology

(Shanahan et al., 2021)	Multicenter, retrospective, cross-sectional study Data was obtained from the Pediatric Health Information System	Study population included a total of 466,696 infant visits across 49 hospitals. When looking at hospital practice patterns, 111,310 infants were included Infants less than 12 months with a diagnosis of bronchiolitis seen in an emergency department (ED) between 2010 and 2018 were included in the analysis The analysis of outcomes was limited to infants presenting between January 1, 2015, and December 31, 2018 Infants with complex chronic conditions, as defined by the pediatric complex chronic condition's classification, were excluded	Characterization of the trends and outcomes associated with the use of bronchodilators for bronchiolitis	Bronchodilator use decreased from 51.5% to 22.8% between the years 2010-2018 No significant difference in hospital admissions, intensive care admissions, or ED return visits was seen when comparing hospitals with high rates of early bronchodilator use to those with low rates of bronchodilator use Males, older infants, Black, non-Hispanic, and those that were publicly insured were more likely to receive bronchodilators	The focus of this study was on characterizing trends related to bronchodilator use for the management of bronchiolitis in hospitals with high versus low use of bronchodilators. While an overall decrease in the rate of bronchodilator use from 2010-2018 was seen, there was no significant change in patient outcomes associated with decreased use

(Spindler et al., 2023)	Descriptive, retrospective cohort study	This study included a total of 265 patients less than two years of age who were admitted on the general pediatric ward of a tertiary-care children's hospital with a diagnosis of bronchiolitis 143 participants were categorized as high-risk (either <12 weeks of age, gastrointestinal age<35 weeks, or with a diagnosis of congenital heart failure, chronic lung disease, or neuromuscular disease), while 122 participants were categorized as standard-risk	Comparison of bronchiolitis management in high-risk and standard-risk patients	The standard-risk group received albuterol more frequently (65.6%) than the high-risk group (44.1%) The use of more than 3 bronchodilator doses was 28.7% in the standard-risk group and 23.8% in the high-risk group Albuterol use was consistent among all groups admitted to pediatric intensive care	This study compares bronchodilator administration in high-risk and standard-risk infants with bronchiolitis. It was determined that the standard-risk infants received bronchodilators, both single administration and multiple administration, more frequently than the high-risk infants

Appendix 3

Cai, Z., Lin, Y., & Liang, J. (2020). Efficacy of salbutamol in the treatment of infants with bronchiolitis: A meta-analysis of 13 studies. *Medicine*, *99*(4), e18657. https://doi.org/10.1097/MD.0000000000018657

Summary

Cai et al., (2020) sought to evaluate the efficacy of salbutamol in the treatment of bronchiolitis. Authors performed a systematic review and meta-analysis of 13 randomized controlled trials (RCT). The results of the analyzed data established those infants treated with bronchodilators experienced an increase in respiratory rate and heart rate. Furthermore, no statistically significant difference was seen in oxygen saturation, clinical severity score, or length of hospitalization between the control groups and groups that received salbutamol.

Analysis

This study included thirteen RCTs published between 1994 and 2015. While the authors did perform a quality evaluation using the Cochrane Risk of Bias Assessment, two RCTs evaluated showed a high risk of reporting incomplete outcome data. Limitations included a potential for overestimation or underestimation of bronchiolitis in the RCTs, as well as an inability to obtain characteristic data from the original studies. Additionally, the authors reported that they eliminated many articles due to insufficient data, which may have led to bias in their conclusions.

Application

Contrary to results published by Barati et al., (2022), study findings provide evidence that salbutamol may increase heart rate and respiratory rate in infants with bronchiolitis. This has the potential to prove the negative impact of bronchodilator therapy in infants with bronchiolitis.

Dowling SK, Gjata I, Solbak NM, Weaver CGW, Smart K, Buna R, & Stang AS. (2020). Group-facilitated audit and feedback to improve bronchiolitis care in the emergency department. *CJEM*, *22*(5), 678–686. https://doi.org/10.1017/cem.2020.374

Summary

Dowling et al., (2020) sought to decrease the rate of low-value care, such as the administration of bronchodilators, in patients with bronchiolitis. This was done by providing physicians with their practice and peer comparator data via group-facilitated audits. Data was then collected for six months following the group-facilitated feedback session. Analysis revealed that for participants that were not admitted to the hospital, 17.9% received salbutamol in the baseline period, while 10.8% received salbutamol during the intervention period. Of those admitted to the hospital, 21.1% were administered salbutamol during the baseline period compared to 15.7% during the intervention period.

Analysis

This was a large study with 78% of emergency physicians consenting to receive their audit and feedback reports. Additionally, 3,883 patients aged 12 months and younger with a diagnosis of bronchiolitis were included. This study included four seasons pre-intervention, while only one season was included post-intervention. In addition, a higher proportion of cases was admitted in the intervention period (28%) as compared to the baseline period (23%). This could be due to the severity of the bronchiolitis seen in the intervention period.

Application

Similarly to Dunn et al., (2020) and Feder et al., (2019), this research article can be used to provide a potential intervention to decrease bronchodilator use in the bronchiolitis population. Group-facilitated feedback sessions do lead to a decrease in bronchodilator use.

Dunn M, Muthu N, Burlingame CC, Gahman AM, McCloskey M, Tyler LM, Ware EP, & Zorc JJ. (2020). Reducing albuterol use in children with bronchiolitis. *Pediatrics*, *145*(1). https://doi.org/10.1542/peds.2019-0306

Summary

Dunn et al., (2020) evaluated the efficacy of pathway changes combined with provider education to reduce the number of patients receiving bronchodilators for bronchiolitis. To implement the pathway changes and education, a multidisciplinary quality improvement team was assembled. A quasi-experimental design was then used to assess the impact of the intervention period. Authors found that the proportion of infants with bronchiolitis who received albuterol in the emergency department (ED) decreased from 43% in the pre-intervention period to 20% after the intervention. Additionally, in the inpatient setting a decrease in albuterol use from 18% pre-intervention to 11% post-intervention was seen.

Analysis

This study was a large study consisting of 3,834 emergency department visits and 1,119 inpatient hospitalizations. Three winter seasons were included from 2014 to 2017. There is a potential that some patients seen with bronchiolitis were overlooked due to a difference that may be seen with diagnosis codes. Additionally, patients treated in an intensive care unit were not included in the study. Finally, as the updated pathway and bronchiolitis management education were released at the same time, it is hard to determine which intervention was most effective.

Application

This article combines both education and a pathway change to improve adherence to bronchiolitis guidelines. It can be used to provide further evidence of the benefits of interventions on bronchiolitis management.

Feder J, Bijelic V, Barrowman N, McDonald J, Murchison B, Jetty R, Tjahjadi A, Parker K, Pothos M, & Pound CM. (2019). The impact of implementing a preprinted order form for inpatient management of otherwise healthy children admitted to a tertiary care centre with a diagnosis of bronchiolitis. *Paediatric Child Health*, *24*(8), 495–501. https://doi.org/10.1093/pch/pxy191

Summary

Feder et al., (2019) aimed to determine the effects of a preprinted order (PPO) set on length of stay (LOS) and resource utilization. This was completed using a retrospective chart review of children admitted to the Children's Hospital of Eastern Ontario. Mean LOS decreased from 3.1 days preintervention period to 2.8 days postintervention. In addition, a decrease in salbutamol nebulizers from 38% to 18% and salbutamol inhalers from 28% to 16% was observed.

Analysis

A total of 245 pediatric patients with bronchiolitis were included in this study. Patients were excluded if they had a history of congenital heart disease, a history of chronic lung disease, a history of genetic conditions, or any neurological impairment. Several limitations to this study exist, including a difficulty to infer causality due to the quasi-experimental independent pretest post-test design. Additionally, a variation in the clinical definition of bronchiolitis exists, which might have impacted the selection of patients, contributing to the small sample size.

Application

This article provides strong evidence that a PPO set can decrease the amount of salbutamol nebulizers and inhalers in patients with bronchiolitis. It can be used as further evidence that interventions can lead to improved bronchiolitis guideline adherence.

Gong C, Byczkowski T, McAneney C, Goyal MK, & Florin TA. (2019). Emergency department management of bronchiolitis in the United States. *Pediatric Emergency Care*, *35*(5), 323–329. https://doi.org/10.1097/PEC.0000000000001145

Summary

Gong et al., (2019) compared bronchiolitis management strategies between pediatric emergency departments (PEDs) and general emergency departments (GEDs). In this cross-sectional study, authors extracted data from the National Hospital Ambulatory Medical Care Survey (NHAMCS) and used a logistic regression to evaluate the type of emergency department and the medications used. They found that while more pediatric patients are treated for bronchiolitis in GEDs, bronchodilator use for the management of these patients was more common in PEDs (weighted percentages 69% vs. 48.6%). Furthermore, they found no significant change in bronchodilator use in either setting before or after the publication of the national guidelines.

Analysis

This was a national study that included children younger than 24 months with a diagnosis of bronchiolitis seen in PEDs or GEDs between the years of 2002 to 2011. While 751 visits were recorded in (NHAMCS) in this period, a weighted estimate was applied, thus representing 2.5 million visits. Furthermore, due to the use of an existing data set and historical examination, certain management variables such as illness severity were not captured. In addition, given the need to use weighted national estimates, interrupted time series analysis was not possible.

Application

In combination with studies from Spindler et al., (2023) and Hester et al., (2021) this study provides insight into factors that may lead to an increased use of bronchodilators in bronchiolitis management. This study specifically focuses on settings with increased use.

Hester G, Nickel AJ, Watson D, & Bergmann KR. (2021). Factors associated with bronchiolitis guideline nonadherence at US children's hospitals. *Hospital Pediatrics*, *11*(10), 1102–1112. https://doi.org/10.1542/hpeds.2020-005785

Summary

Hester et al., (2021) explored factors associated with nonadherence to national bronchiolitis guidelines at 52 children's hospitals across the United States. They found that 19.3% of emergency department (ED) encounters and 32.7% of inpatient encounters were nonadherent to bronchiolitis guidelines in regard to management with bronchodilators. Additionally, authors found that older patients, non-Hispanic Black patients, and those being seen for a secondary encounter were more likely to be prescribed bronchodilators, while American Indians were less likely to receive bronchodilator therapy. Finally, it was noted that pediatricians, nurse practitioners, and physician's assistants were less likely to order bronchodilators than pediatric emergency medicine physicians.

Analysis

This was a large study that included 198, 028 patients aged 1 month to 2 years that were seen in an ED or admitted with bronchiolitis between January 2016 and December 2018. As this study is a retrospective administrative database study, provider reasoning is not included. Additionally, the database did not identify where an intervention occurred, meaning the metrics for admitted patients may not reflect the behavior of inpatient providers.

Application

Similarly to Huang et al., (2024) and Shanahan et al., (2021), this article focuses on factors that may lead to nonadherence with current bronchodilator guidelines. In combination with these articles, it can be used to assess risk factors for increased bronchodilator use.

House SA, Marin JR, Hall M, & Ralston SL. (2021). Trends over time in use of nonrecommended tests and treatments since publication of the American Academy of Pediatrics Bronchiolitis Guideline. *JAMA Network Open*, *4*(2), e2037356. https://doi.org/10.1001/jamanetworkopen.2020.37356

Summary

House et al., (2021) sought to evaluate the trends in bronchiolitis management since the original publication and update of the American Academy of Pediatrics (AAP) guidelines. The authors performed a retrospective, observational hospital cohort study using the Pediatric Health Information Systems (PHIS) database to accomplish their goal. Results showed that from the original publication in 2006, to the guideline update in 2014, a 13.5% decrease in bronchodilator use for the treatment of bronchiolitis was seen in emergency departments (ED). Additionally, an 11.3% decrease was seen in inpatient use. Furthermore, after the publication of the updated guidelines, the ED saw the negative monthly trajectory steepen from -0.11% to -0.26%, and the inpatient group saw the negative monthly trajectory improve further from -0.08% to -0.26%.

Analysis

This large study included 602,375 children aged 28 days to 2 years who were discharged with a diagnosis of bronchiolitis between November 1st 2006, to December 31, 2019. Data was extracted from the PHIS database which accounts for approximately 20% of pediatric hospitalizations in the United States. Due to the use of administrative data, one major limitation to this study is that patient acuity cannot be assessed.

Application

As an alternative to other studies included in this review, this article provides evidence that a decrease in bronchodilator use has been seen since the publication of AAP guidelines.

Huang, J., Moss, A., Hoyt, B. M., Watson, J. D., & Brittan, M. S. (2024). Factors associated with inhaled bronchodilator and oral corticosteroid use in young children with first lower respiratory tract infection. *The Journal of Pediatrics, 267*. https://doi.org/10.1016/j.jpeds.2024.113912

Summary

Huang et al., (2024) evaluated factors associated with the use of bronchodilators in pediatric patients with lower respiratory tract infections (LRTI). This was completed using a retrospective cohort study that evaluated data from the Colorado All Payer Claims Database. The study found that 14.4% of patients had a bronchodilator claim at or within seven days of the LRTI diagnosis. Additionally, older age, male sex, atopy, public insurance, non-inpatient settings, and prior bronchodilator or steroid claims were associated with bronchodilator prescription. Alternatively, a history of complex chronic conditions or asthma family history showed no association with bronchodilator claims.

Analysis

This was a large study including 10,194 patients with claims that included bronchiolitis, wheezing, and pneumonia. While wheezing and pneumonia were included, a sensitivity analysis was conducted to ensure conditions such as asthma were excluded. The limitations of this study included inaccuracy of claims data, underestimation of asthma prevalence, and the inability to imply causation.

Application

Much like Shanahan et al., (2021) and Hester et al., (2021), this study describes factors that may be associated with an increased use of bronchodilators in the management of bronchiolitis. This information may be helpful in providing insight into risk factors for overuse.

Lawrence J, Hiscock H, Voskoboynik A, Walpola R, & Sharma A. (2023). Impact of an intervention to reduce bronchodilator use in bronchiolitis—A time series analysis. *Hospital Pediatrics*, *13*(8), 653–659. https://doi.org/10.1542/hpeds.2022-007059

Summary

Lawrence et al., (2023) assessed the impact of a multifaceted intervention on rates of bronchodilator use for treatment in those with bronchiolitis. Interventions included education, clinician audit-audit feedback, and an electronic medical record (EMR) alert. This quality improvement study used an interrupted time series analysis and a poisson regression analysis to determine the monthly count data for bronchodilator orders and assess the impact of the intervention over time. Authors found that males, those over nine months of age, and those that were admitted had higher rates of bronchodilator use. After the intervention period, a decrease in bronchodilator orders from 6.9% to 3.2% was seen. Of the patients who were prescribed bronchodilators, reasons for overriding the EMR alert included the patient being close to 12 months old, a previous response to bronchodilators, and a family history of asthma.

Analysis

Data for this study was extracted for all children under the age of 1 year who had a diagnosis of bronchiolitis between 2016 and 2022. A total of 4,635 infants were included preintervention, and 4,948 were included postintervention. Limitations of the study include an inability to report causation. Additionally, the intervention was only implemented and tested in one system.

Application

This article can be used in combination with research performed by Molloy et al., (2019) and Dunn et al., (2020) to provide further evidence of the benefits of interventions on decreasing bronchodilators in bronchiolitis management.

Maki K, Azizi H, Hans P, & Doan Q. (2021). Adherence to national paediatric bronchiolitis management guidelines and impact on emergency department resource utilization. *Paediatric Child Health, 26*(2), 108–113. https://doi.org/10.1093/pch/pxaa013

Summary

Maki et al., (2021) focused on the association between the use of salbutamol and corticosteroids on the frequency of return visits and length of stay (LOS) in a pediatric emergency department (PED) in those with bronchiolitis. Authors conducted a retrospective case control study of infants seeking care at the BC Children's Hospital between December 1st, 2014, and April 24th, 2017. Analysis revealed that of the 185 study participants, 64 received salbutamol in the PED, and 50 were instructed to continue the salbutamol upon discharge. Furthermore, authors noted that the use of salbutamol was associated with a mean 58.3-minute increase in PED LOS.

Analysis

This study included 185 patients that were seen at one children's hospital. Authors were able to adjust data for acuity of index visit, age, severe tachypnea, oxygen desaturation, and dehydration when analyzing the data. Limitations of the study include the nature of the retrospective chart review, as the completeness and accuracy of the data is dependent upon individual clinicians charting. In addition, authors only included children with documentation stating that this was the child's first-time presentation for wheeze or respiratory illness. If this was not appropriately recorded children may have been excluded.

Application

This study provides evidence that while the use of bronchodilators is not indicated in the management of bronchiolitis, bronchodilators remain highly administered in this population.

Molloy MJ, Tamaroff J, McDaniel L, & Genies MC. (2019). Targeted education across clinical settings improves adherence to evidence-based interventions for bronchiolitis. *Clinical Pediatrics*, *58*(11–12), 1284–1290. https://doi.org/10.1177/0009922819852982

Summary

Molloy et al., (2019) utilized a pre-post intervention study to determine the effects of an educational intervention on the use of bronchodilators in the management of bronchiolitis. In addition, authors created a bronchiolitis standardized electronic medical record (EMR) documentation phrase that emphasized clinical practice guidelines. The researchers noted that in the pediatric emergency department (PED), 62.5% of children received bronchodilators prior to the intervention, while only 22.7% received bronchodilators post-intervention. Less significantly, in the inpatient setting a total of 22.2% of participants received bronchodilators pre-intervention, with 17.8% receiving bronchodilators post-intervention.

Analysis

This study included 136 participants pre-intervention and 185 participants post-intervention for a total of 321 participants. This study was limited given the small sample size, and as it is a single-center study, the results may not be broadly applicable. Additionally, this intervention targeted residents who participated in patient care both in the PED and in the inpatient setting, which may have artificially improved the impact of the intervention. Furthermore, nonresident physician providers were not targeted, and thus the educational intervention may not have reached them.

Application

Like Lawerence et al., (2023) this study provides further evidence that changes in the EMR system can be beneficial in decreasing the use of bronchodilators in bronchiolitis.

Pinto JM, Schairer JL, & Petrova A. (2016). Duration of hospitalization in association with type of inhalation therapy used in the management of children with nonsevere, acute bronchiolitis. *Pediatric Neonatology*, *57*(2), 140–144. https://doi.org/10.1016/j.pedneo.2015.04.014

Summary

Pinto et al., (2016) evaluated the association between different types of pharmacological therapy, including bronchodilators, and the length of stay (LOS) of children with bronchiolitis. To evaluate this association, authors conducted a retrospective review of the medical records of children with bronchiolitis seen at the Jersey Shore University Medical Center. Authors compared the effects of 1.25 mg/3mL albuterol in an isotonic standard solution, 1.25 mg/3mL of albuterol with 4 mL of 3% hypertonic saline, 4 mL of 3% hypertonic saline alone, and no inhaled treatments. Authors found that 27.2% of participants received albuterol alone, and that those that received albuterol had higher respiratory scores on average than those in the other groups. Additionally, it was determined that there was no significant difference in LOS between patients who were treated with bronchodilators when compared with those who received no therapies.

Analysis

195 children aged two years or less, born at term gestation, without chronic conditions, without evidence of pneumonia, and without admission to the intensive care unit were included in this study. Authors utilized various strategies to decrease bias in data collection, however a risk of bias remains. A second study limitation is associated with the use of a single inpatient setting.

Application

This study provides further evidence that bronchodilators do not significantly impact clinical outcomes, such as LOS, associated with bronchiolitis.

Rivera-Sepulveda AV, Rebmann T, Gerard J, & Charney RL. (2019). Physician compliance with bronchiolitis guidelines in pediatric emergency departments. *Clinical Pediatrics*, *58*(9), 1008–1018. https://doi.org/10.1177/0009922819850462

Summary

Rivera-Sepulveda et al., (2019) evaluated provider knowledge, attitudes, perceived barriers, and perceived usefulness regarding the use of bronchodilators for the management of bronchiolitis. This was accomplished using a cross-sectional survey that included a sample of providers that currently practice pediatric emergency medicine. Researchers found that 97.7% of participants reported knowledge of the current practice guidelines, however further analysis revealed that only 8.9% of participants had never used them, 43% rarely used them, 40.7% sometimes used them, and 7.4% used them most of the time or always. Additionally, it was determined that providers who agreed with the science behind the guidelines were more likely to be compliant with bronchodilator recommendations.

Analysis

The survey was distributed in the fall of 2017, prior to the start of the bronchiolitis season. This benefited the study, as provider answers were not affected by the potential for changes in epidemiology, as could happen during the season. The study sample was small with a total of 214 physicians completing the survey. Additionally, the survey used self-reported use of therapeutic modalities, and may not accurately reflect the actual behavior of the physicians in practice.

Application

This study providers physician insight into compliance with the national guidelines for bronchodilator management.

Shanahan, K. H., Monuteaux, M. C., Nagler, J., & Bachur, R. G. (2021). Early use of bronchodilators and outcomes in bronchiolitis. *Pediatrics*, *148*(2), e2020040394. https://doi.org/10.1542/peds.2020-040394

Summary

Shanahan et al., (2021) assessed outcomes that were associated with the use of bronchodilators in those with bronchiolitis. A multicenter, retrospective, cross-sectional study was performed using data from the Pediatric Health Information System. The study included pediatrics less than 12 months of age with a diagnosis of bronchiolitis that were seen in an emergency department. While it was determined that bronchodilator use decreased from 51.5% to 22.8% from 2010-2018, results showed that 32% of infants treated still received bronchodilators. Factors associated with administration included male gender, older age, Black, non-Hispanic, and those publicly insured. Additionally, when comparing hospitals with high and low early use of bronchodilators, no significant differences in admissions, return visits, noninvasive ventilation, or invasive ventilation was seen.

Analysis

This was a large study which included 466,696 bronchiolitis encounters from 49 hospitals. Of these encounters, 111,310 infants were included in the hospital level analysis looking at hospitals with high and low rates of early use of bronchodilator therapy. Study limitations include insufficient patient-level data leading to an inability to quantify illness severity and the potential for recording errors given the nature of administrative data.

Application

In combination with studies performed by Huang et al., (2024) and Hester et al., (2021), this study can be used to provide evidence of current bronchodilator overuse.

Spindler D, Monroe KK, Malakh M, McCaffery H, Shaw R, Biary N, Foo K, Levy K, Vittorino R, Desai P, Schmidt J, Saul D, Skoczylas M, Chang YK, Osborn R, & Jacobson E. (2023). Management practices for standard-risk and high-risk patients with bronchiolitis. *Hospital Pediatrics*, *13*(9), 833–840. https://doi.org/10.1542/hpeds.2022-006518

Summary

Spindler et al., (2023) aimed to compare bronchiolitis management in patients with standard-risk and high-risk bronchiolitis. This was completed using a descriptive, retrospective cohort study that was performed in a tertiary-care children's hospital. The results of the study showed that patients categorized in the standard-risk group received albuterol more frequently than those placed in the high-risk category (standard-risk 65.6% vs. high-risk 44.1%). Additionally, the use of more than three doses was reported as 28.7% in the standard-risk group and 23.8% in the high-risk group.

Analysis

This study included 265 patients, divided into two categories, standard-risk and high-risk. Patients were considered high-risk if they were <12 weeks of age, had a gestational age <35 weeks, or if they had chronic lung disease, congenital heart disease, or neuromuscular disease. 143 patients were categorized as high-risk, while 122 were categorized as standard-risk. Study limitations include that the study described a single institution and that the definition of high-risk may vary among researchers.

Application

This article provides further information on bronchodilator over-use, as well as factors in which bronchodilators may be ordered for those with bronchiolitis.

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