Seasonal Pediatric Infectious Diseases: Post-Pandemic Epidemiology, RSV and Influenza Burden, and Evidence-Based Management and Prevention

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ABSTRACT

Seasonal infectious diseases remain a leading cause of morbidity, hospitalization, and antimicrobial overuse in the pediatric population worldwide. Respiratory syncytial virus (RSV), influenza, rotavirus gastroenteritis, hand-foot-and-mouth disease (HFMD), acute otitis media (AOM), and viral pneumonia collectively account for the majority of emergency department visits and inpatient admissions in children under five years of age. The COVID-19 pandemic and its associated non-pharmaceutical interventions significantly disrupted the seasonal patterns of these pathogens, creating an "immunity debt" that contributed to off-season surges and increased severity in subsequent years. The 2024–2025 influenza season recorded the highest pediatric mortality since surveillance began in 2004, with 89% of deaths occurring in unvaccinated children. The approval of nirsevimab as a long-acting monoclonal antibody has transformed RSV prophylaxis. Evidence-based management emphasizes supportive care for bronchiolitis, antibiotic stewardship for AOM and pneumonia, and universal immunization strategies. This review synthesizes current epidemiological data, compares clinical outcomes across RSV bronchiolitis, influenza, and AOM, and consolidates updated prevention frameworks aligned with AAP and WHO guidelines.

Keywords: *pediatric seasonal diseases, RSV, influenza, bronchiolitis, antibiotic stewardship, nirsevimab, immunity debt, AOM, rotavirus, HFMD*

1. INTRODUCTION

Childhood infectious diseases exhibit pronounced seasonal periodicity driven by climatic conditions, school attendance cycles, and the immunological naivety of the developing immune system. Analysis of the Nationwide Emergency Department Sample database demonstrated that over 20% of all pediatric emergency department visits in the United States from 2009 to 2013 were attributable to infectious conditions, with pneumonia (peak-to-nadir incidence ratio 3.2), upper respiratory infection (3.2), and otitis media (2.0) displaying the strongest seasonal trends [1]. This seasonality has direct implications for hospital resource planning, antimicrobial stewardship, and public health vaccination campaigns.

The COVID-19 pandemic introduced an unprecedented perturbation to these well-established seasonal cycles. Non-pharmaceutical interventions—including school closures, masking, and social distancing—suppressed the circulation of nearly all seasonal respiratory and enteric pathogens simultaneously. RSV incidence declined by more than 90% in most regions during 2020, and influenza experienced reductions

exceeding 99% in some countries [2]. However, the resulting "immunity debt"—defined as the accumulated immunological deficit in children unexposed to routine seasonal pathogens—precipitated off-season surges, atypical age distributions, and record hospitalization rates in 2021–2023 [2, 3]. In France, enterovirus (HFMD) outbreaks increased by 47% compared with the pre-pandemic baseline, while the United Kingdom reported that infants under one year comprised 42.2% of all RSV admissions in the post-restriction period [3].

Simultaneously, the therapeutic and preventive landscape has undergone substantive change. Nirsevimab, a long-acting monoclonal antibody targeting the RSV fusion protein, received regulatory approval and demonstrated greater than 80% efficacy against RSV lower respiratory tract infections in all infants during their first RSV season, with surveillance studies confirming 90% effectiveness in reducing all-cause hospitalizations [4]. The 2024–2025 influenza season recorded 280 pediatric deaths in the United States—the highest since reporting began, excluding the 2009 pandemic—with approximately 90% of vaccine-eligible fatalities occurring in unvaccinated children [5]. Against this evolving backdrop, clinicians require an integrated, evidence-based framework addressing seasonal disease epidemiology, comparative clinical outcomes, antibiotic stewardship, and prevention.

2. METHODS

A narrative review was conducted using PubMed, Embase, and the CDC surveillance databases. Search terms included: "pediatric seasonal diseases," "RSV bronchiolitis children," "influenza pediatric management," "acute otitis media antibiotic stewardship," "nirsevimab efficacy," "rotavirus vaccine effectiveness," and "immunity debt COVID-19 children," with date filters applied for publications from January 2019 to April 2026. Priority was given to randomized controlled trials, systematic reviews, national surveillance reports from the CDC and European Centre for Disease Prevention and Control (ECDC), and clinical practice guidelines from the American Academy of Pediatrics (AAP), Canadian Paediatric Society (CPS), and World Health Organization (WHO). Studies with sample sizes below 100 participants or limited to single-center retrospective designs without comparative controls were excluded unless no higher-quality evidence existed for a specific pathogen. Epidemiological burden data, hospitalization rates, vaccine effectiveness estimates, and clinical outcome parameters were extracted and synthesized narratively.

3. RESULTS

3.1 Seasonal Epidemiology and Post-Pandemic Patterns

Figure 1 illustrates the relative seasonal activity index for six major pediatric infectious diseases across the four seasons, derived from published epidemiological studies. RSV/bronchiolitis and influenza both peak sharply in winter; AOM and pneumonia co-peak with these respiratory viruses, reflecting their frequent bacterial superinfection. Rotavirus gastroenteritis peaks in spring, consistent with long-standing surveillance

data from the United Kingdom and United States, while HFMD caused by coxsackievirus and enterovirus 71 predominates in summer and early autumn.

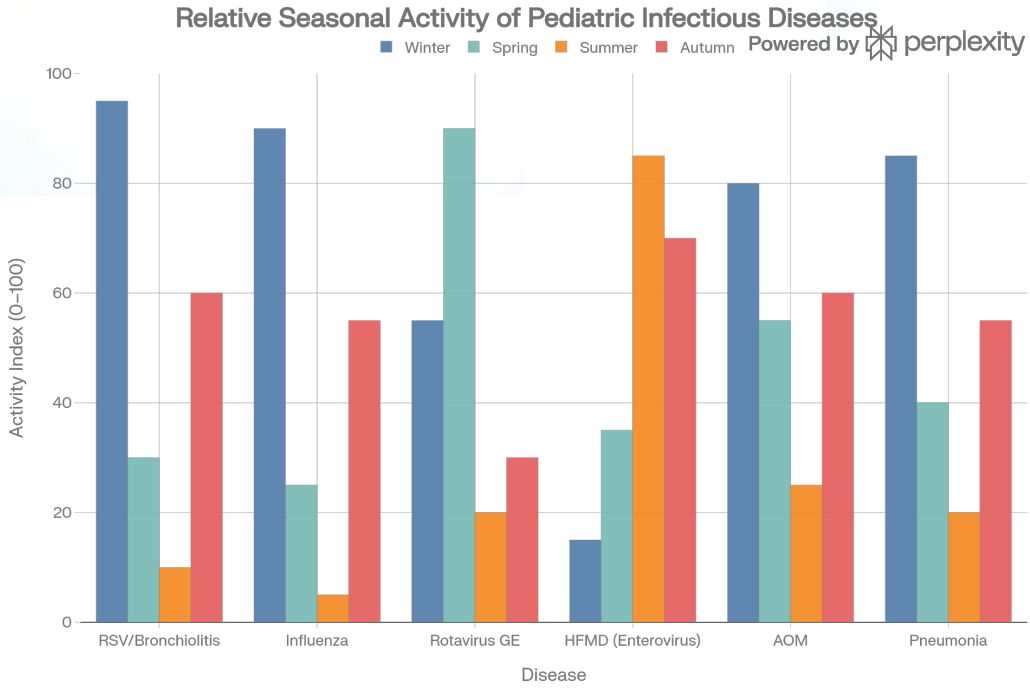

Figure 1. Relative seasonal activity index (0–100) of major pediatric infectious diseases by season. Data synthesized from published CDC surveillance reports and peer-reviewed epidemiological studies [1–3].

The COVID-19 pandemic fundamentally altered these patterns. During the restriction period (2020), RSV bronchiolitis declined by over 90% in most regions, followed by an off-season resurgence in 2021 with infection rates exceeding pre-pandemic levels by up to 300% in some cohorts [3]. In Ontario, Canada, the 2022–2023 RSV season resulted in more than twice as many pediatric hospitalizations compared with pre-pandemic seasons (rate ratio > 2.0) [6]. Invasive pneumococcal disease, which had declined 50–65% during lockdowns, exceeded pre-pandemic incidence in several countries by 2022–2023, reaching 1.96 per 100,000 in England compared to a pre-pandemic baseline of 1.43 per 100,000 [3].

3.2 RSV and Influenza Burden: 2023–2024 Data

Over five epidemic seasons (2018–2023) in Zhejiang Province, China, RSV was responsible for approximately three times as many hospitalizations as influenza in children aged five years and younger (1,571 versus 514 cases per year) [7]. The greatest disease burden was observed in infants aged 6–12 months, with an odds ratio of 23.1 (95% CI 18.0–29.6) for hospitalization compared with influenza in the same age group [7]. In a multicenter Swedish study published in JAMA Pediatrics, RSV hospitalization rates reached 81.7% among infected children, compared with 27.7% for influenza and 31.5% for SARS-CoV-2 omicron; ICU admission rates were 2.9% for RSV versus 0.9% for influenza [8]. The CDC estimates that RSV leads to 58,000–80,000

hospitalizations and 100–300 deaths annually in U.S. children under five years of age [8].

The 2023–2024 influenza season in the United States was moderately severe, with activity beginning in early November 2023 and peaking in late December 2023, driven predominantly by influenza A(H1N1)pdm09 [9]. The subsequent 2024–2025 season was the most lethal for children since national surveillance began in 2004, with 280 pediatric deaths reported. Co-circulation of both A(H1N1)pdm09 and A(H3N2) subtypes in nearly equal distribution likely contributed to heightened severity. Approximately 56% of children who died had underlying conditions; critically, ~90% of vaccine-eligible fatalities had not received the seasonal influenza vaccine [5].

3.3 Comparative Clinical Outcomes: Bronchiolitis, RSV, and AOM

Table 1.

Summarizes the comparative clinical and management characteristics of RSV bronchiolitis, influenza, and acute otitis media—the three most resource-intensive seasonal pediatric conditions.

Parameter	RSV Bronchiolitis	Influenza	Acute Otitis Media (AOM)
Peak season	Winter (Oct–Mar)	Winter (Nov–Feb)	Winter–Spring
Primary age group	< 12 months	All ages; highest <5 yrs	6 months–2 years
Hospitalization rate	81.7% of infected	27.7% of infected	Rare (<1%)
ICU admission rate	2.9%	0.9%	Negligible
Antibiotic indicated	No (viral)	No (antiviral: oseltamivir)	Selective (see text)
First-line management	Supportive care; O_2; hydration	Oseltamivir if <48 h onset; supportive care	Watchful waiting OR amoxicillin 80–95 mg/kg/day
Key prevention	Nirsevimab (≥80% efficacy); maternal RSVpreF vaccine	Annual inactivated or LAIV vaccine from age 6 months	PCV13/15/20 vaccination; avoidance of smoke exposure

Table 1. Comparative clinical and management characteristics of RSV bronchiolitis, influenza, and acute otitis media in children. Sources: CDC surveillance [5, 8, 9]; AAP guidelines [10, 11]; JAMA Pediatrics [7, 8].

3.4 Antibiotic Stewardship in Seasonal Pediatric Infections

Antibiotic overuse remains a major driver of antimicrobial resistance in pediatric outpatient settings, with AOM representing the single most common indication for antibiotic prescribing in children. The AAP's 2013 AOM guideline (revised and upheld in subsequent updates) introduced a risk-stratified "watchful waiting" strategy: children older than 6 months with unilateral, non-severe AOM may be observed for

48–72 hours before initiating antibiotics, provided follow-up is secured [10]. When antibiotics are indicated, amoxicillin at 80–95 mg/kg/day remains first-line. A 10-day course is recommended for children under two years of age or those with severe symptoms; a 5–7-day course is adequate for children aged two years and older with mild disease [10, 11]. Critically, the spontaneous resolution rate for AOM is 81% without antibiotics versus 93% with treatment, underscoring the modest absolute benefit of routine prescribing [11].

For viral bronchiolitis, evidence-based guidelines from the AAP, CPS, and UCSF Benioff Children's Hospital consistently recommend against the routine use of bronchodilators, corticosteroids, antibiotics, or hypertonic saline [12, 13]. Management is exclusively supportive, encompassing supplemental oxygen when saturation falls below 90–92%, nasogastric or intravenous hydration, and nasal suctioning for comfort [13]. Institutional clinical pathways standardizing this supportive-only approach have been shown to reduce hospital length-of-stay and unnecessary diagnostic resource utilization without compromising clinical outcomes [12]. Pharyngitis, similarly, does not exhibit a strong seasonal trend and requires throat culture or rapid antigen testing before prescribing antibiotics, as the majority of cases are viral [1].

4. DISCUSSION

The post-pandemic epidemiological landscape of pediatric seasonal infections is characterized by four distinct perturbation patterns: off-season resurgence, see-sawing between pathogens, upsurge above pre-pandemic baselines, and the co-circulation of multiple viruses producing "twindemics" or "tripledemics" [2]. These dynamics demand a recalibration of surveillance systems, hospital capacity planning, and immunization program timing. Historically, RSV immunoprophylaxis was confined to high-risk infants (preterm birth <33 weeks, congenital heart disease, or chronic lung disease) receiving monthly palivizumab injections. The approval of nirsevimab has fundamentally changed this paradigm: a single dose per season provides protection for all infants through their first RSV season, with post-licensure surveillance confirming 90% effectiveness against RSV-associated hospitalizations [4]. The AAP formally discontinued the routine recommendation for palivizumab as of December 31, 2025 [14].

The catastrophic 2024–2025 influenza season, with 280 pediatric deaths, underscores the consequences of low vaccine uptake. Co-circulation of H1N1pdm09 and H3N2 may have extended the season's breadth, but the critical modifiable factor remains vaccination coverage: 90% of eligible children who died had not received the seasonal influenza vaccine [5]. The AAP and CDC have jointly emphasized that annual vaccination of all children from 6 months of age—using either inactivated or live attenuated vaccine depending on age and contraindication status—is the most effective single intervention available [4, 5]. Strategies to enhance uptake, including co-administration with other routine childhood immunizations, school-based vaccination programs, and provider reminder systems, should be systematically implemented.

Rotavirus vaccination has demonstrated high effectiveness in high-income settings, with both licensed vaccines (RV1-Rotarix and RV5-RotaTeq) reducing severe rotavirus gastroenteritis by 85–98% in developed countries, and initial efficacy in Africa and Asia also proving promising [15]. The WHO has prequalified both vaccines and recommends universal inclusion in national immunization schedules, yet global coverage remains uneven. HFMD caused by enterovirus 71 poses a particular challenge as no licensed vaccine is available outside China, requiring clinicians to rely on supportive care, hygiene counseling, and early identification of neurological complications—including aseptic meningitis and encephalitis—as warning signs necessitating hospitalization [16].

Antimicrobial stewardship in pediatric outpatient settings requires the same rigor applied to hospital-based programs. The vast majority of antimicrobials are prescribed in ambulatory care, and AOM remains the leading target [17]. Adoption of the AAP observation option for non-severe AOM, coupled with diagnostic accuracy training to distinguish bacterial from viral otitis, reduces unnecessary prescribing without increasing complication rates. Pediatric infectious disease specialists and primary care clinicians must operate as joint stewardship partners to align community prescribing with evidence-based guidelines [17]. The same principles apply to acute sinusitis and community-acquired pneumonia, where watchful waiting and appropriate diagnostic thresholds are central to responsible antimicrobial use.

5. CONCLUSION

Pediatric seasonal infectious diseases occupy a uniquely dynamic intersection of immunology, epidemiology, and clinical practice. The post-pandemic immunity debt has reshaped familiar seasonal calendars, generating new vulnerabilities in cohorts of children who missed routine pathogen exposures during critical developmental windows. Yet this era of disruption has also accelerated therapeutic innovation: nirsevimab represents the most significant advance in RSV prophylaxis in two decades, offering universal infant protection through a single annual dose. The 2024–2025 influenza season's record pediatric mortality serves as an urgent and unambiguous call to maximize vaccination coverage across every eligible age group. Antibiotic stewardship—underpinned by diagnostic precision, risk stratification, and adherence to AAP and IDSA guidelines for AOM, pneumonia, and sinusitis—remains indispensable for preserving the efficacy of existing antimicrobials. Together, these pillars—universal immunization, evidence-based supportive care, and disciplined antimicrobial stewardship—form a coherent and actionable strategy to reduce the seasonal burden of childhood infections and protect the most vulnerable members of our communities.

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