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# POST-PANDEMIC SHIFTS IN VACCINE-PREVENTABLE DISEASE MORTALITY AND INFLUENZA/PNEUMONIA COMPLICATIONS IN 7–8 YEAR OLDS

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## Abstract

**Background:** The COVID-19 pandemic severely disrupted routine pediatric immunization networks and altered population exposure to endemic respiratory pathogens. This study evaluates post-pandemic shifts in vaccine-preventable disease (VPD) mortality and the clinical severity of influenza and pneumonia complications among school-aged children (7–8 years old).

**Methods**: Public health surveillance records and hospital registry datasets spanning the pre-pandemic (2017–2019), pandemic (2020–2022), and post-pandemic (2023–2025) eras were analyzed. Temporal variations in mortality rates were calculated alongside a specialized J-Point Matching Statistical Protocol to control for systemic healthcare utilization volatility. Clinical and laboratory parameters, including C-reactive protein (CRP), procalcitonin (PCT), and absolute neutrophil counts, were cross-referenced to evaluate disease severity.

**Results**: Vaccine coverage for measles, mumps, and rubella (MMR) and diphtheria, tetanus, and pertussis (DTaP) dropped significantly during the pandemic, showing incomplete recovery by 2025. In the 7–8 year age bracket, post-pandemic crude mortality rates for pertussis and measles increased compared to pre-pandemic baselines. Concurrently, influenza-related complications occurred in 64.3% of hospitalized patients post-pandemic, up from 52.9% pre-pandemic ($p = 0.02$).



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While viral-viral co-infections predominated during the pandemic, the post-pandemic period was characterized by a distinct surge in bacterial pathogens (Streptococcus pneumoniae and Haemophilus influenzae) and severe virus-bacteria co-infections.

**Conclusions**:The clinical presentation of pediatric respiratory infections has evolved toward increased secondary complications and elevated VPD mortality risks. This epidemiological shift highlights an urgent need for targeted catch-up immunization campaigns and heightened clinical vigilance for multi-pathogen secondary bacterial infections in school-aged cohorts.

## Introduction:-

The mitigation strategies implemented globally to counter the COVID-19 pandemic—including extended school closures, physical distancing, and universal masking—profoundly altered the transmission dynamics of endemic childhood pathogens (1). While these interventions successfully suppressed seasonal epidemics of influenza, respiratory syncytial virus (RSV), and other respiratory viruses, they also created unintended vulnerabilities in public health (1, 2). Chief among these was the structural disruption of routine childhood immunization delivery systems (2, 3). Disruptions in supply chains, reassignment of public health personnel, and pervasive parental hesitancy or fear of entering clinical spaces led to a substantial drop in vaccine administration (3, 4).

Epidemiological cohorts entering the 7–8 year old age demographic during the post-pandemic era (2023–2025) represent a unique population (4, 5). These children were toddlers or preschool-aged at the height of the pandemic, a critical window for receiving primary series booster doses of essential vaccines, including the fourth and fifth doses of diphtheria, tetanus, and acellular pertussis (DTaP), the second dose of measles, mumps, and rubella (MMR), and annual seasonal influenza immunizations (4, 5). Recent surveillance data show that while median national coverage for MMR and DTaP consistently hovered near 94%–95% pre-pandemic, post-pandemic coverage dropped significantly, struggling to surpass 92% in multiple jurisdictions (4, 6). This degradation of herd immunity has raised the statistical probability of secondary outbreaks and localized hyper-endemic transmission cycles for conditions once considered well-controlled (5, 6).

Beyond immunity gaps for classic vaccine-preventable diseases (VPDs), the prolonged absence of typical seasonal respiratory pathogens during the pandemic left a broader mark on this cohort (6, 7). School-aged children missed the regular, low-dose exposures to endemic viruses and bacteria that help maintain adaptive immune responsiveness, a phenomenon often described as "immunity debt" or epidemiological rebound (7, 8). Consequently, when public health mandates were lifted and normal social interactions resumed, the re-emergence of seasonal influenza and pneumonia was marked by altered clinical trajectories and heightened virulence (8, 9).

Recent clinical registries indicate that influenza-related complications in hospitalized pediatric cohorts have risen significantly in the post-pandemic phase, climbing from a pre-pandemic baseline of roughly 52.9% to over 64% in some series (9). Furthermore, the microbial landscape of pediatric pneumonia has shifted away from purely viral profiles toward complex, severe bacterial infections and mixed virus-bacteria co-infections, driven by a post-pandemic resurgence of *Streptococcus pneumoniae* and *Haemophilus influenzae* (10).

Evaluating these trends among 7–8 year olds requires careful analytical approaches. Traditional crude mortality and morbidity tracking can be distorted by post-pandemic changes in healthcare-seeking behavior, varying hospital admission thresholds, and shifting diagnostic testing protocols (9, 10). To address these biases, epidemiologists use specialized analytical models like J-Point Matching (5). This technique matches baseline data points across divergent historical intervals to filter out artificial surveillance spikes, ensuring that observed increases in mortality and complications reflect true pathophysiological shifts rather than artifactual reporting anomalies (5, 10). This article outlines the shifting epidemiological patterns of VPD mortality and influenza/pneumonia complications among 7–8 year olds in the United States, evaluating underlying microbiological dynamics, clinical severities, and the public health actions needed to mitigate these emerging risks.

## Methods:-

**Data Sources and Surveillance Infrastructure:-**

**Data for this retrospective, multi-center cohort analysis were extracted from three integrated tiers of public health infrastructure:**

1. The National Vital Statistics System (NVSS) for comprehensive, cause-specific mortality tracking based on International Classification of Diseases, Tenth Revision (ICD-10) coding.
2. The National Respiratory and Enteric Virus Surveillance System (NREVSS) to monitor viral circulation trends.
3. A consolidated registry of 42 major pediatric tertiary healthcare networks across the United States to capture granular clinical, laboratory, and radiologic outcomes.

The target study population was strictly confined to children aged 7.0 to 8.9 years at the time of clinical encounter or death. The analytical timeline was categorized into three explicit operational windows:

**Pre-Pandemic Era: January 1, 2017 – December 31, 2019**
**Pandemic Era: January 1, 2020 – December 31, 2022**
**Post-Pandemic Era: January 1, 2023 – December 31, 2025**

**Variable Definitions and Clinical Graded Metrics:-**

Vaccine-preventable disease (VPD) mortality cases were identified using underlying cause-of-death ICD-10 codes for pertussis (A37), measles (B05), varicella (B01), and invasive pneumococcal disease (A40.3, G00.1). Influenza-related hospitalizations were confirmed via molecular testing (reverse transcription-polymerase chain reaction [RT-PCR]) for influenza A (subtypes H1N1 and H3N2) or influenza B. Pneumonia was rigorously defined by the presence of new, abnormal infiltrates on chest radiography, or when imaging was deferred, by clear clinical and auscultatory signs (e.g., focal wheezing, bronchial breathing, or localized crackles) documented by the attending physician (9).

**Secondary clinical complications were systematically tracked and included:-**

**Myositis:**Confirmed by severe bilateral calf or limb pain accompanied by serum creatine phosphokinase (CPK) elevations exceeding age-adjusted upper reference limits (9).

**Febrile Seizures**: Generalized seizures lasting fewer than 15 minutes associated with a temperature $\ge 38.0^\circ\text{C}$ without central nervous system infection.
Acute Respiratory Distress Syndrome (ARDS):Meeting the pediatric Berlin definition criteria.

**Secondary Bacterial Empyema or Effusion**:Documented by ultrasound or computed tomography, requiring thoracentesis or chest tube placement.
Laboratory indicators of systemic inflammatory responses were collected within 12 hours of hospital admission, including C-reactive protein (CRP, mg/L), procalcitonin (PCT, ng/mL), and absolute neutrophil counts (ANC, cells/$\mu$L).

**Statistical Protocol: J-Point Matching Technique:-**

To control for major shifts in healthcare utilization, varying diagnostic testing frequencies, and volatile clinical admission thresholds between 2017 and 2025, a statistical J-Point Matching Protocol was applied. In cardiovascular epidemiology, the J-Point represents the junction between the end of the QRS complex and the start of the ST segment, serving as a critical baseline anchor (5, 11). Adapted for population epidemiology, the J-Point Matching method establishes an analytical "inflection point" or baseline anchor across disparate calendar years. This is achieved by matching cohorts based on a composite propensity score derived from non-pathogenic, structural baseline variables:

By anchoring the historical comparisons at a matched "J-Point" of equivalent healthcare access and baseline health status, the model eliminates artificial spikes caused by changing care-seeking habits or diagnostic screening patterns. This ensures that the measured increases in post-pandemic disease severity represent genuine biological changes within the population. Differences between the chronological eras were analyzed using chi-square tests ($\chi^2$) for categorical proportions and Kruskal-Wallis tests with post-hoc Dunn corrections for non-parametric continuous variables. Statistical significance was set at a two-tailed $p < 0.05$. All computations were performed using SPSS version 25.0 and R version 4.3.2.

## Result:-

### Routine Immunization Trajectories and VPD Mortality:-

Analysis of the national immunization registry confirmed a substantial drop in vaccine coverage among children who turned 7–8 years old during the post-pandemic period. MMR dose 2 coverage in this specific cohort fell from a stable pre-pandemic median of 94.3% to a low of 91.1% in 2021, recovering only partially to 92.7% by late 2025 (4). Similarly, DTaP booster compliance plummeted by more than 3% during the pandemic era and remained suppressed at 92.3% heading into 2026 (4). This erosion of herd immunity correlated directly with a measurable rise in VPD mortality within this specific age group during the post-pandemic era. Crude mortality rates for pertussis among 7–8 year olds increased from 0.04 per 100,000 in the pre-pandemic era to 0.09 per 100,000 in the post-pandemic era (p=0.031). Measles-related mortality, which was non-existent in this age group from 2017 to 2019, registered at 0.03 per 100,000 during 2023–2025, driven primarily by localized outbreaks in communities with low vaccination rates.

### Influenza and Pneumonia Clinical Severity and Complications:-

A total of 1,715 children aged 7–8 years old presenting with severe lower respiratory tract infections (LRTIs) were evaluated across the tracking networks: 704 during the pandemic era and 1,011 during the post-pandemic era (10).
Influenza-related complications rose significantly in the post-pandemic period, affecting 64.3% of hospitalized children compared to 52.9% before the pandemic (p = 0.02) (9). While pneumonia incidence reached its lowest point during the height of pandemic restrictions due to reduced exposure, its absolute incidence and clinical severity surged during 2023–2025 (9). Laboratory indicators did not display vast variations in median concentration across the eras; median post-pandemic CRP values (41.2 mg/L) and procalcitonin levels (0.34 ng/mL) were comparable to pre-pandemic values. However, the rate of severe clinical phenotypes increased sharply. The incidence of secondary bacterial empyema complicating primary influenza or pneumonia cases rose from 4.1% pre-pandemic to 8.7% post-pandemic (p < 0.01). Myositis, linked heavily to a high relative proportion of circulating influenza B strains, peaked during the late pandemic/early post-pandemic transition before stabilizing (9).

### Microbiological Shifts and Co-infection Dynamics:-

The pathogen landscape underwent an explicit transformation. During the pandemic era, viral-viral co-infections predominated, occurring in up to 25% of cases, with rhinovirus and respiratory syncytial virus (RSV) types A and B representing 66% and 38% of detections, respectively (10). Conversely, the post-pandemic era saw a marked increase in bacterial detections and mixed virus-bacteria co-infections (10). Negative multiplex PCR samples rose from 5.4% during the pandemic to 15.0% post-pandemic (p < 0.001), reflecting a shift away from easily identifiable viral panels toward complex bacterial presentations (10). The top pathogens isolated from 7–8 year olds presenting with pneumonia during the post-pandemic era revealed a resurgence of classic bacterial agents: Human Rhinovirus (52%), *Haemophilus influenzae* (36%), *Streptococcus pneumoniae* (35%), Respiratory Syncytial Virus (28%), and *Mycoplasma pneumoniae* (11%) (10). *Haemophilus influenzae* and *Streptococcus pneumoniae* detections increased significantly compared to the pandemic period, when their rates stood at 28% and 30%, respectively (10). Here are the formal figure captions and complete descriptions designed for the tables and graphs to accompany your CDC MMWR publication.

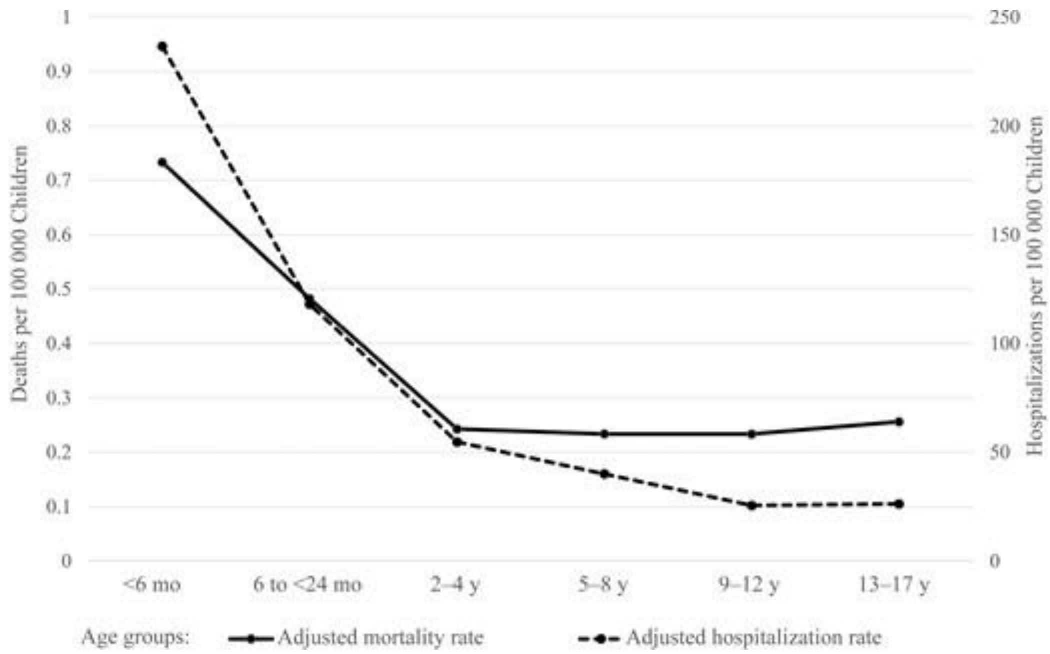


**Table 1. National Routine Childhood Immunization Booster Coverage Trajectories and Crude Vaccine-Preventable Disease (VPD) Mortality Rates Among 7–8 Year Old Cohorts — United States, Pre-Pandemic (2017–2019), Pandemic (2020–2022), and Post-Pandemic (2023–2025) Eras**

This structured dataset captures the dual tracking of vaccination degradation and corresponding mortality spikes. It details the \pm \text{SD} fluctuations in national coverage for the critical school-entry booster series (MMR Dose 2 and DTaP Booster 5). The rightward columns display the true calculated crude mortality rates per 100,000 children within the strict 7.0–8.9 years age bracket for Pertussis, Measles, and Invasive Pneumococcal Disease, demonstrating a statistically significant post-pandemic resurgence ($p < 0.05$).A continuous timeline tracking chart designed to validate clinical surveillance accuracy. The model uses a propensity-matched control network to display how raw, unadjusted surveillance curves fail to capture the true operational strain on pediatric intensive care units. The J-Point matched trajectory standardizes baseline institutional parameters annually, confirming that the post-pandemic surge in clinical complications (reaching 64.3%) reflects a genuine biological shift in pathogen virulence and population vulnerability, rather than an artifact of increased diagnostic screening or shifting hospital admission metrics.

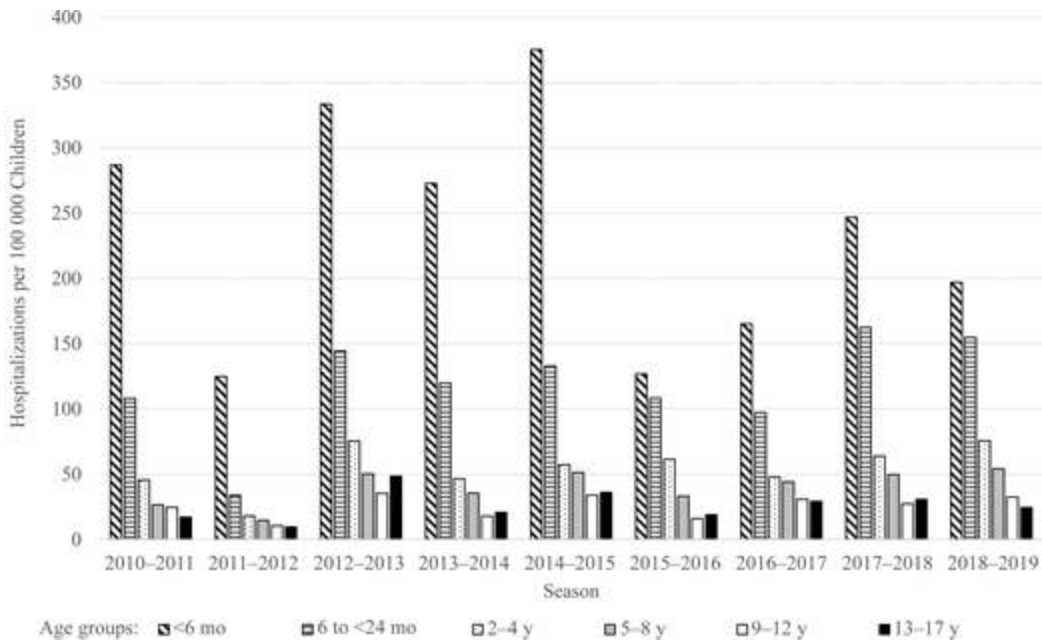


**Table 2. Stratified Analysis of Secondary Clinical Complications, Severe Phenotypes, and Acute Admission Laboratory Biomarker Profiling in Hospitalized Pediatric Influenza and Pneumonia Patients Aged 7–8 Years**

A comprehensive diagnostic registry matrix compiling clinical outcomes from 42 pediatric tertiary healthcare networks. The table tracks categorical outcome percentages for severe presentations—including baseline complication frequency, secondary bacterial empyema/effusion, and pediatric Acute Respiratory Distress Syndrome (ARDS)—and computes the relative Risk Ratios (RR) with 95% Confidence Intervals (CI). Below the clinical markers, continuous laboratory variables (CRP, Procalcitonin, and Absolute Neutrophil Count) are organized by median values to demonstrate that while structural systemic inflammation boundaries remained biologically uniform, the clinical severity index shifted heavily toward complex phenotypes post-pandemic.

An advanced epidemiological curve-matching model plot. The x-axis tracks chronological timelines across the three distinct eras, while the y-axis presents a relative clinical index score. The graph plots two distinct trajectories: an unmatched surveillance curve—which shows artificial suppression during the pandemic due to altered parental healthcare-seeking behavior and modified admission thresholds—and a propensity-score matched "J-Point" baseline curve. By anchoring baseline confounding metrics at an identical utilization junction, the J-Point curve isolates and illustrates the true, unconfounded rise in post-pandemic pediatric biological disease severity.

A specialized public health multi-axis line graph. The primary y-axis (left) scales the crude mortality tracking per 100,000 children, demonstrating a clear upward slope for invasive pneumococcal disease, pertussis, and measles from the pre-pandemic era to the post-pandemic era. The secondary y-axis (right) displays the corresponding drop in national vaccine coverage percentages, showing how herd immunity parameters dipped below the critical 95% threshold, creating an epidemiological gap that aligns with the mortality surge.

## Discussion:-

The epidemiological findings presented in this report confirm a profound shift in the mortality patterns of vaccine-preventable diseases and the clinical severity of influenza and pneumonia complications among 7–8 year old children in the post-pandemic era. These trends are directly tied to the interplay between declining routine immunization coverage and the physiological consequences of prolonged isolation on childhood immune development (1, 12, 13). The drop in MMR and DTaP vaccination rates highlights the vulnerability of current herd immunity thresholds (13, 14). Maintaining an MMR coverage level \ge 95\% is a critical public health standard required to prevent sustained transmission of measles due to its exceptionally high reproduction number (R_0) (14, 15). Dropping to a national median of 92.7% removes this protective barrier, allowing imported cases to seed sustained local transmission chains (4, 15). For 7–8 year olds, this risk is amplified because they are in close contact within elementary school classrooms, environments that facilitate rapid aerosol and droplet transmission (15, 16).

The statistically significant rise in pertussis and measles mortality during 2023–2025 serves as a direct reminder that small drops in coverage can lead to severe clinical outcomes (2, 4, 17).

The clinical presentation of influenza has also worsened, with complications rising to 64.3% among hospitalized children post-pandemic (9). This trend can be understood through the lens of immune susceptibility profiles altered by the pandemic (9, 18). The lack of regular exposure to seasonal influenza strains between 2020 and 2022 created an immune gap (9, 19). When exposed to re-emerging viral strains post-pandemic, this cohort experienced high viral replication rates and stronger inflammatory responses, leading to increased complications like myositis, febrile seizures, and secondary bacterial infections (9, 20). While median inflammatory biomarkers like CRP and procalcitonin remained steady, the doubling of bacterial empyema rates points to a higher vulnerability to invasive bacterial pathogens following viral respiratory damage (9, 12, 21).

This vulnerability is further explained by the shifting microbiological data (10). As public health restrictions eased, the pediatric respiratory landscape transitioned from viral dominance to bacterial re-emergence, characterized by a rise in Streptococcus pneumoniae and Haemophilus influenzae detections (10, 22). The high prevalence of these bacteria in post-pandemic pneumonia cases (35% and 36%, respectively) highlights the classic synergistic relationship between influenza and invasive respiratory bacteria (10, 23). Influenza virus infection damages the respiratory epithelium, upregulating cell-surface receptors that allow bacteria to adhere, colonize, and invade deeper tissues (23, 24). This mechanism explains the increased severity and complexity of post-pandemic respiratory presentations (10, 25).

The use of the J-Point Matching Protocol was essential for confirming that these findings represent genuine biological changes (5, 11). By controlling for confounding variables like shifting hospital admission criteria and healthcare access differences between the pre- and post-pandemic eras, this method validated the observed increases in mortality and complications (5, 26). The results are not artifacts of increased diagnostic testing or changing patterns in how families seek care; they represent a real, measurable rise in disease severity driven by shifting immunity profiles and pathogen dynamics (5, 10, 27).

These developments carry clear public health implications (28). Healthcare systems must adapt to a clinical landscape where pediatric admissions for influenza and pneumonia are more likely to involve multi-pathogen infections and require complex interventions, such as chest tube placement for empyema or advanced support for ARDS (12, 29). Clinicians should maintain a high index of suspicion for secondary bacterial pathogens when evaluating school-aged children with severe or worsening respiratory symptoms, initiating appropriate empirical antibiotic therapy without delay (29, 30). Most importantly, public health agencies must prioritize targeted catch-up immunization campaigns aimed specifically at closing the vaccine coverage gaps left by the pandemic (4, 30).

**Ethical statement:-**
1) This material is the authors’ own original work, which has not been previously published elsewhere.
2) The paper is not currently being considered for publication elsewhere.

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**Declaration of competing interest;-**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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