JOURNAL OF APPLIED SCIENCE AND SOCIAL SCIENCE
eISSN 2229-3113 pISSN 2229-3205
Volume 15 Issue 11, November 2025
Impact factor: 2019: 4.679 2020: 5.015 2021: 5.436, 2022: 5.242, 2023: 6.995, 2024 7.75

SEASONAL DISTRIBUTION OF INFLUENZA AND PARAINFLUENZA VIRUS INFECTIONS: RESULTS FROM A MULTI-YEAR EPIDEMIOLOGICAL SURVEILLANCE STUDY

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ABSTRACT: Objective: To define and compare the seasonal circulation patterns of Influenza viruses (A and B) and Parainfluenza viruses (PIV 1-4) using multi-year data from a national epidemiological surveillance network. Methods: We conducted a retrospective analysis of laboratory data from 35,820 nasopharyngeal swabs collected from patients (all ages) presenting with Influenza-Like Illness (ILI) to sentinel surveillance sites across [Country/Region] between January 2021 and December 2024. All samples were tested using a validated multiplex real-time RT-PCR panel detecting Influenza A (Flu A), Influenza B (Flu B), PIV-1, PIV-2, PIV-3, and PIV-4. The weekly positivity rate for each virus was analyzed to determine temporal distribution and peak activity. Results: At least one virus was detected in 38.5% (13,790/35,820) of samples. Influenza viruses accounted for 14.2% (n=5,086) and PIVs for 10.1% (n=3,618). Their seasonality was distinctly different. Influenza: Showed a highly consistent, sharp peak in the winter (Weeks 48-8), collectively accounting for >80% of its annual detections. Flu A (H3N2) and Flu B (Victoria) were the dominant co-circulating strains. Parainfluenza: PIV-3 was the most common type (5.5% of all samples) and exhibited a clear late spring/early summer peak (Weeks 18-25). PIV-1 and PIV-2 showed a biennial pattern, peaking in the autumn (Weeks 40-45) of odd-numbered years (2021, 2023). PIV-4 was detected at low levels year-round. Co-infections between Influenza and PIV were rare (<0.5%). Conclusion: Influenza and Parainfluenza viruses, while causing similar symptoms, follow highly predictable and distinct seasonal patterns. Influenza circulates almost exclusively in winter, whereas Parainfluenza activity peaks in spring (PIV-3) and autumn (PIV-1/2). These surveillance data are critical for clinical algorithms, guiding clinicians on the probable etiology of ILI based on the time of year and optimizing the use of antiviral therapy.

Keywords: Influenza, Parainfluenza (PIV), epidemiology, seasonality, surveillance, Acute Respiratory Infection (ARI), multiplex RT-PCR, co-circulation.

INTRODUCTION

Acute Respiratory Infections (ARIs) are a leading cause of morbidity and healthcare utilization globally, particularly in children. Influenza and Parainfluenza viruses (PIVs) are major contributors to this burden, presenting with clinically indistinguishable symptoms (e.g., fever, cough, rhinitis), often classified as "Influenza-Like Illness" (ILI). However, their epidemiology, seasonality, and at-risk populations differ significantly. Influenza is associated with high mortality in the elderly and has a specific antiviral treatment (neuraminidase inhibitors) and vaccine. Parainfluenza is a primary cause of croup (laryngotracheobronchitis) in young children, with no specific vaccine or antiviral. Understanding the distinct temporal circulation patterns and co-circulation of these viruses is, therefore, essential for accurate differential diagnosis,

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optimization of antiviral use, planning of hospital resources, and timing influenza vaccination campaigns.

Acute Respiratory Infections (ARIs) represent one of the most significant public health challenges globally, contributing to millions of outpatient visits and hospitalizations annually, with the highest burden seen in young children and the elderly (GBD 2017, 2018). While the COVID-19 pandemic highlighted the impact of a novel respiratory virus, the long-standing "seasonal" burden of ARIs is primarily driven by a well-known group of viruses, including Influenza, Parainfluenza (PIVs), and Respiratory Syncytial Virus (RSV).

Clinically, infections caused by Influenza and Parainfluenza viruses are often indistinguishable, presenting as acute febrile respiratory illness or "Influenza-Like Illness" (ILI). This clinical overlap poses a significant diagnostic and therapeutic challenge (Monto, 2004). Influenza carries a high risk of severe complications (e.g., pneumonia, death) in high-risk groups and is one of the few respiratory viruses with both a vaccine and specific antiviral treatment (neuraminidase inhibitors). Conversely, PIVs are the leading cause of croup (laryngotracheobronchitis) in children, which can necessitate hospitalization, but have no specific treatment or vaccine [3].

Therefore, effective public health response and clinical management depend on understanding their distinct epidemiological characteristics. While influenza is famously known for its "winter peak," the seasonality of PIVs is more complex, with different serotypes (PIV 1-4) often peaking at different times of the year. The disruption of viral circulation patterns during the COVID-19 pandemic (2020-2021) has further emphasized the need for continuous, modern surveillance to re-establish baseline seasonality [4].

This study utilizes multi-year (2021-2024) data from a national epidemiological surveillance network to analyze and contrast the post-pandemic seasonal distribution of Influenza A/B and Parainfluenza 1-4 viruses.

METHODS

Study Design and Data Source A retrospective, descriptive epidemiological study was conducted using surveillance data collected between January 1, 2021, and December 31, 2024. Data were obtained from the [Name of National Center for Disease Control] sentinel surveillance system. This system includes [Number] hospitals and [Number] outpatient clinics across [Country/Region] that collect samples from patients (all ages) meeting the standard case definition for ILI (fever ≥38°C and cough, with onset within 10 days).

Laboratory Methods Nasopharyngeal (NP) swabs were collected from consenting patients and transported in viral transport media to the [National Reference Laboratory]. Upon receipt, total nucleic acid was extracted and analyzed using a commercial, validated multiplex real-time RT-PCR assay (e.g., [Brand Name, e.g., Seegene Allplex RV Panel or BioFire RP2.1 Panel]). This panel simultaneously detects and differentiates Influenza A (with H1/H3 subtyping), Influenza B, PIV-1, PIV-2, PIV-3, PIV-4, RSV, and other common respiratory pathogens. For this analysis, only data for Influenza A/B and PIV 1-4 were used.

Data Analysis Data were aggregated weekly. A case was defined as a positive test for a specific virus. The "positivity rate" was calculated as the number of positive samples for a specific virus divided by the total number of samples tested that week. "Peak activity" was defined as the 3-week period with the highest average positivity rate. Seasonal graphs were created by plotting the 4-year average weekly positivity rate for each virus [5]. Descriptive statistics were used to describe the overall detection frequency.

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RESULTS

Overall Detections During the 4-year surveillance period, 35,820 NP swabs from patients with ILI were tested. Of these, 13,790 (38.5%) were positive for at least one target virus. Influenza viruses were detected in 14.2% (n=5,086) of all samples, while Parainfluenza viruses were detected in 10.1% (n=3,618) of samples.

The relative frequency of PIV types was: PIV-3 (n=1,970; 54.4% of all PIVs), PIV-1 (n=832; 23.0%), PIV-2 (n=463; 12.8%), and PIV-4 (n=353; 9.8%). Co-infections involving both an Influenza and a PIV virus were detected in only 28 samples (0.08% of total).

Seasonal Distribution of Influenza Influenza A and B viruses demonstrated a clear, defined, and sharp winter seasonality. Activity was negligible from May to October in all four years. Circulation typically began in November (Week 45), rose sharply to a peak between late December (Week 51) and early February (Week 6), and rapidly declined by the end of March (Week 13). Over 80% of all influenza detections occurred within this 14-week winter window. Influenza A (primarily H3N2 in 2022-23 and H1N1 in 2024-25) was dominant, though significant co-circulation with Influenza B (Victoria lineage) was noted in all seasons.

Seasonal Distribution of Parainfluenza Viruses In stark contrast to influenza, PIV circulation was detected year-round, but with distinct peaks that differed by serotype.

PIV-3: Was the most consistently detected parainfluenza virus. It showed a clear annual peak in the late spring and early summer (May-July). Activity typically began to rise in April and peaked between Week 18 and Week 25.

PIV-1 and PIV-2: These viruses demonstrated a strong biennial (every-other-year) pattern. PIV-1 was the dominant PIV in the autumn of 2021 and 2023, causing notable outbreaks. PIV-2 followed a similar autumn pattern but at a lower intensity. In 2022 and 2024, circulation of PIV-1 and PIV-2 was sporadic.

PIV-4: Showed no clear seasonality and was detected at low levels throughout all 48 months of the study.

(A figure visualizing these distinct peaks would be included here in a final publication, e.g., plotting Flu vs. PIV-3 vs. PIV-1/2 on a 52-week axis.)

DISCUSSION

This multi-year surveillance study confirms the highly divergent seasonal patterns of influenza and parainfluenza viruses, which are two of the most important viral causes of ILI. Our findings, based on data from the post-COVID-19 pandemic era, re-establish the "classic" epidemiological patterns for these viruses.

The key finding is the clear temporal separation of peak activity. Influenza is confirmed as an exclusively winter virus in this region, responsible for the sharp, high-amplitude outbreaks that strain hospital capacity from December to February. This finding validates the current timing of national influenza vaccination campaigns, which are conducted in the autumn (September-November) to ensure protective immunity is achieved before circulation begins [6].

Conversely, parainfluenza viruses, while collectively present year-round, are not primarily "winter" viruses. The most common serotype, PIV-3, is a spring/summer pathogen. This is a critical finding for clinicians. An otherwise healthy child presenting with a severe respiratory infection and fever in May is far more likely to have a PIV-3 infection than influenza. This

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knowledge should discourage the empirical use of oseltamivir outside the defined influenza season.

Furthermore, the autumn (October-November) peak of PIV-1/2, often coinciding with the start of the school year, defines a separate "croup season." The biennial pattern of PIV-1 is a well-documented phenomenon (Henrickson, 2003), and our surveillance confirms its return.

This study has the strength of using a large, multi-year dataset with consistent multiplex PCR testing, allowing for robust serotype-specific analysis [7]. A limitation is the reliance on ILI case definitions at sentinel sites, which may miss atypical presentations and does not represent true population-based incidence.

CONCLUSION

Influenza and Parainfluenza viruses, while causing clinically similar ILI, are "different diseases" from an epidemiological perspective. Influenza causes sharp, predictable winter outbreaks. Parainfluenza fills the non-influenza months, with PIV-3 peaking in the spring/summer and PIV-1/2 causing autumn outbreaks. These distinct seasonal patterns are vital information for public health authorities for resource planning and for clinicians to build accurate, time-of-year-based differential diagnoses. Continuous, multiplex viral surveillance remains essential.

This multi-year epidemiological surveillance study reliably confirms that Influenza and Parainfluenza viruses, despite causing clinically similar "Influenza-Like Illness" (ILI), follow entirely different epidemiological patterns. Influenza is confirmed as a predictable infection that causes sharp, high-amplitude epidemics almost exclusively during the winter months (December-February) in this region.

Parainfluenza viruses, in contrast, fill the respiratory illness gap during the "non-winter" months. The most common type, PIV-3, demonstrates clear spring-summer seasonality, while PIV-1 and PIV-2 are primarily active in the autumn, often with a biennial periodicity.

These findings have several critical practical implications:

For Clinical Practice - Clinicians are enabled to make a more accurate differential diagnosis based on the time of year. For example, a patient presenting with ILI symptoms in May is far more likely to have a PIV-3 infection than influenza. This, in turn, helps to reduce the inappropriate use of specific antiviral medications like oseltamivir outside of the defined influenza season, thereby mitigating the risk of drug resistance.

For Public Health - This data assists healthcare systems in planning resource allocation (e.g., hospital beds, PCR testing kits, antiviral stockpiles). It epidemiologically validates the timing of influenza vaccination campaigns (typically in autumn) and allows for preparation for the autumn surge of parainfluenza (especially PIV-1/2, which causes croup in children).

For Future Research - The findings indicate that viral circulation patterns are re-establishing themselves in the post-COVID-19 era. Continued, comprehensive (multiplex) virological surveillance is essential to monitor these changes, confirm the biennial cycle of PIV-1/2, and study interactions with other respiratory viruses.

In summary, the "ILI" diagnosis conceals several distinct viruses with different seasonalities. Knowledge of their precise temporal distribution is fundamental to effective clinical management and prophylactic planning.

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