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Seasonal Trends, Subtype Distribution and Demographic Burden of Influenza Virus Infections: A Three-Year Surveillance Study

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ABSTRACT

Background: Influenza remains a significant public health concern, causing seasonal outbreaks with variable intensity and severity. The evolution of circulating subtypes and their differential impacts across age groups and clinical presentations necessitate ongoing surveillance to guide vaccination and treatment strategies.

Objectives: To examine the epidemiological characteristics, subtype distribution, and demographic burden of influenza virus infections over three consecutive influenza seasons (2022–2025), and to compare findings with national and global data.

Methods: A prospective observational study was conducted on 797 patients presenting with Influenza-like Illness (ILI) or Severe Acute Respiratory Infection (SARI). Real-time reverse transcription polymerase chain reaction (RT-PCR) was used to detect and subtype influenza viruses. Demographic, clinical, and virological data were analysed year-wise, by subtype, sex, age group, and clinical severity. Comparative references were drawn from studies by WHO GISRS, ICMR, CDC, and peer-reviewed publications.

Results: Overall Influenza positivity was found to be 27.4%. Yearly Influenza positivity rose from 18.8% (2022–2023) to 36.6% (2023–2024) and it slightly declined to 31.3% (2024–2025). The >1–5 years age group consistently had the highest burden with positivity of 45.3–52.1%. Male patients accounted for 63–71% of total cases. Subtype dominance shifted yearly: Influenza B (Victoria) was predominant in 2022–2023 (76.5%) and 2024–2025 (60.7%), while H1N1pdm09 dominated in 2023–2024 (94.6%). H3N2 resurged in 2024–2025 (38.0%). No Influenza B Yamagata lineage was detected over the past three years. Influenza A subtypes were significantly associated with SARI presentations (H1N1pdm09: 87.7% SARI), while Influenza B also contributed notably to severe illness. Rural areas showed higher positivity (36%) than urban (22.2%).

Conclusion: The study highlights the dynamic epidemiology of influenza with seasonal subtype shifts, age and sex disparities, and a consistent burden among young children. The absence of Influenza B Yamagata over three years suggests its continued global dormancy or extinction. Occurrence of around 30% of Influenza positivity among ARIs cases every year with the most affected age group being children aged 1-5 years and adults >35-60 years, stringent strategies need to be formulated like starting Flu clinics, active and passive surveillance of Influenza cases before and during Influenza seasons, and implementation of Influenza vaccine programs, especially in children.

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1. INTRODUCTION

Influenza viruses are among the most important respiratory pathogens globally, contributing to annual epidemics and periodic pandemics. Seasonal influenza is caused by Influenza A and B viruses, which undergo constant antigenic changes that affect their transmissibility, virulence, and vaccine efficacy.[1] Monitoring subtype distribution, demographic susceptibility, and seasonal trends is vital to optimize public health responses, including immunization campaigns and clinical management protocols.

Post-COVID-19 pandemic years have seen changes in influenza circulation patterns, influenced by immunity gaps, reduced population mobility, and changes in health behavior.[2,3] This study aimed to assess the epidemiology of influenza over a three-year period (2022–2025), focusing on subtype dynamics, age and sex distribution, and severity indicators across urban and rural populations.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

This prospective observational study was conducted at a tertiary care hospital and associated surveillance sites from June 2022 to May 2025. The study population included patients presenting with ILI or SARI as defined by WHO. The protocol of the study was approved by the Institute Ethics Committee.

2.2 Sample Collection and Testing

Oropharyngeal/throat swabs were collected from 797 ILI/SARI patients and tested for influenza viruses using RT-PCR based on WHO protocols over a period of three years (June 2022-May2025. Primer and probes based on CDC-approved sequences were used specific for Influenza A, Influenza B, Influenza A H1N1pdm09, Influenza A H3N2, Influenza B (Victoria lineage) and Influenza B (Yamagata lineage). Samples were first tested for Influenza A and Influenza B. Influenza A-Positive samples were further tested for subtypes Influenza A H1N1pdm09 and Influenza A H3N2, and Influenza B-positive samples were further tested for Victoria or Yamagata lineages.

2.3 Data Analysis

Demographic and clinical variables (age, sex, urban/rural, clinical syndrome) were correlated with influenza positivity and subtype distribution. Seasonal patterns were analysed monthly and annually. Comparative statistical analysis used chi-square tests and odds ratios were applied. Data were compared with ICMR, WHO GISRS, CDC, and peer-reviewed sources.

3. RESULTS

From June 2022 to May 2025, we tested 797 samples of patients suffering from ARIs. Overall, out of the total of 797 samples tested, 218 (27.4%) were positive for influenza viruses and 579 samples (72.6%) were negative for Influenza infection. Influenza positivity was seen as 18.8%, 36.6% and 31.3% in 2022–2023, 2023–2024, and 2024–2025 respectively.

Table 1: Year-wise Influenza subtypes distribution

Year	**2022-23**	**2023-24**	**2024-25**
Inf. A H1N1pdm09	01 (1.6%)	**71(94.6%)**	01 (1.3%)
Inf. A H3N2	14 (21.9%)	01 (1.3%)	30 (38.0%)
Inf. B Victoria lineage	**49 (76.5%)**	03 (4.0%)	**48(60.7%)**
Inf. B Yamagata lineage	00	00	00

Table 2: Age-wise gender distribution of total influenza cases in each year.

Year	**2022-23**		**2023-24**		**2024-25**	
Gender	Male	Female	Male	Female	Male	Female
>1-5 years	17	12	13	09	26	15
>5-15 years	04	01	02	00	03	01

>15-35 years	07	05	05	04	10	07
>35-60 years	12	05	18	05	07	04
>60 years	01	00	15	04	04	02
Total positive	41 (64.1%)	23 (35.9%)	53 (70.7%)	22 (29.3%)	50 (63.3%)	29 (36.7%)

Table 3: Subtype-wise monthly distribution of laboratory-confirmed Influenza Cases in 2022-23

	June 2022 to May 2023												
Subtype	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Total**
Inf. A H1pdm09	00	00	00	01	00	00	00	00	00	00	00	00	01 (1.6%)
Inf. A H3	00	00	00	00	00	00	01	07	00	05	01	00	14 (21.8%)
Inf. B Victoria	00	00	00	00	00	00	00	00	04	33	09	03	49 (76.5%)
Inf. B Yamagata	00	00	00	00	00	00	00	00	00	00	00	00	00

Table 4: Subtype-wise Monthly Distribution of Laboratory-confirmed Influenza Cases in 2023-24

	June 2023 to May 2024												
Subtype	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Total**
Inf. A H1pdm09	00	00	01	00	00	00	02	13	35	19	01	00	71 (94.6%)
Inf. A H3	00	00	00	00	00	00	00	00	01	00	00	00	01 (1.3%)
Inf. B Victoria	00	00	01	00	00	00	00	00	01	01	00	00	03(4.0%)
Inf. B Yamagata	00	00	00	00	00	00	00	00	00	00	00	00	00

Table 5: Subtype-wise Monthly Distribution of Laboratory-confirmed Influenza Cases in 2024-25

	June 2024 to May 2025												
Subtype	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Total**
Inf. A H1pdm09	00	00	00	01	00	00	00	00	00	00	00	00	01 (1.3%)
Inf. A H3	00	00	00	00	00	00	00	00	14	16	00	00	30 (37.9%)
Inf. B Victoria	00	00	00	00	00	00	00	02	20	22	02	02	48 (60.7%)
Inf. B Yamagata	00	00	00	00	00	00	00	00	00	00	00	00	00

Table 6: Age-wise Distribution of Influenza Virus Types, Subtypes, and Lineages with Statistical Significance

Age group (yrs)	Total samples tested	Influenza A positive (%)	Influenza B positive (%)	P value	H1N1pdm09 (%)	H3N2 (%)	P value	Victoria lineage (%)	Yamagata lineage (%)	P value
>1-5 years	197	40 (20.4%)	52 (26.4%)	0.033*	20 (10.2%)	20 (10.2%)	1.00	52 (26.4%)	00	-
>5-15 years	81	05 (6.2%)	06 (7.4%)	0.739	02 (2.5%)	03 (3.7%)	0.682	06 (7.4%)	00	-
>15-35 years	150	13 (8.7%)	25 (16.7%)	0.008*	10 (6.7%)	03 (2%)	0.022*	25 (16.7%)	00	-
>35-60 years	235	36 (15.3%)	15 (6.4%)	<0.001*	24 (10.2%)	12 (5.1%)	0.002*	15 (6.4%)	00	-
>60 years	134	24 (17.9%)	02 (1.5%)	<0.001*	17 (12.7%)	07 (5.2%)	0.013*	02 (1.5%)	00	-

Table 7: Severity-wise distribution of Influenza subtypes from 2022–23 to 2024–25

Subtypes	Inf. A H1N1pdm09		Inf. A H3N2		Inf. B Victoria lineage		Inf. B Yamagata lineage	
Severity group	**ILI**	**SARI**	**ILI**	**SARI**	**ILI**	**SARI**	**ILI**	**SARI**
2022-23	01	00	02	12	13	36	00	00
2023-24	08	63	00	01	00	03	00	00
2024-25	00	01	07	23	11	37	00	00
Total	09 (12.3%)	64 (87.7%)	09 (20%)	36 (80%)	24 (24%)	76 (76%)	00	00

The age-wise distribution of influenza-positive cases over three influenza seasons was analysed. In 2022–2023, among 64 positive cases, the highest proportion was seen in the >1–5 years age group with 29 cases (45.3%) and the least age groups affected were >5–15 years with 5 cases (7.8%) and >60 years with 1 case (1.6%). In 2023–2024, out of 75 positive cases, highest number of Influenza cases was seen in patients with age >35–60 years accounting for 23 cases (30.7%) and the least affected age group was >5–15 years **(**2 cases, 2.7%). During the 2024–2025 season, out of the 79 positive cases, similar to 2022-23, scenario, the majority of the cases was again seen in >1–5 years age group with 41 cases (51.9%), however >60 years age group accounted for 6 cases (7.6%), and the least affected age group was of >5–15 years with 4 cases (5.1%).

Across all three years, males consistently showed higher influenza positivity than females, and the >1–5 years age group was the most affected in both genders, followed by adults in the >35–60 and >60 years age group categories.

Out of 797 samples tested, 503 were from urban population and 294 were from rural population. Out of 503 urban population samples tested 112 (22.2%) were Influenza positive and out of 294 rural population samples tested, 106 (36%) were Influenza positive.

In 2022–2023, the predominant subtype was Inf. B (Victoria lineage) with 49 (76.5%) out of 64 cases followed by Influenza A (H3N2) with 14 cases (21.9%), and Influenza A (H1N1pdm09) with only 1 case (1.6%). In 2023–2024, Influenza A (H1N1pdm09) emerged as the dominant strain with 71 cases (94.6%), while Influenza A H3N2 and Influenza B Victoria were minimal with 1 case (1.3%) and 3 cases (4.0%), respectively. In 2024–2025 similar to 2022-23 the most common subtype was Influenza B (Victoria lineage) with 48 (60.7%) out of 79 cases, followed by Influenza A (H3N2) with 30 cases (38.0%)**,** and a single case of Influenza A H1N1pdm09 (1.3%)**.**

The monthly pattern of 2022-23 and 2024-25 Influenza season (predominant strain: Influenza B-Victoria lineage) was similar with cases starting to increase from February, peaking in March and continued till May. However, the 2023-24 (predominant strain: Influenza A H1N1pdm09) season demonstrated a typical Influenza pattern as has been seen in previous years with Influenza A predominance with cases typically appearing in peak winters (December month), peaking in late February and subsiding as the winters get over by April month.

Out of the total of 218 Influenza positive cases, 146 were SARI cases (67%) and 42 were ILI cases (33%). Out of 73 Influenza A H1N1pdm09, 45 Influenza A H3N2 and 100 Influenza B (Victoria) positive cases, SARI was seen in 64 cases (87.7%), 36 cases (80%) and 76 cases (76%) respectively.

4. DISCUSSION

In the present study, the overall influenza virus infection positivity over the past three years was detected as 27.4% of with acute respiratory infection (ARI), indicating a substantial burden of ILI and SARI in the community. These findings align with ICMR reports (15–35%) and WHO GISRS positivity data (10–40%).[4,5,6]

In the present study, year-wise distribution of influenza subtypes from 2022 to 2025 showed dynamic shifts in circulating viral strains in each year. In 2022–2023, Influenza B (Victoria lineage) was the dominant strain, accounting for 76.5% of the total of 64 positive cases. However, the IDSP-IHIP data from health facilities till 5th March 2023 reported H3N2 as the predominant strain with 459 cases, followed by Influenza B (91 cases) and Influenza A H1N1pdm09 (41 cases).[7] The 2023–2024 season was marked by a dramatic dominance of H1N1pdm09, which contributed to 94.6% of all Influenza cases, a significant shift that nearly excluded other subtypes. In a WHO update on Influenza activity in USA during the 2023-24 season, the Influenza A H1N1pdm09 was reported as the predominant strain during the winter season.[8] In 2024–2025, the viral landscape shifted once again, with Influenza B Victoria lineage was again the dominating strain (60.7%). Across all three years, Influenza B Yamagata lineage was consistently absent, suggesting non-circulation or extinction, a trend also reflected in global data.[9] These alternating subtype predominance patterns are consistent with global and national influenza surveillance reports, which frequently show annual shifts in circulating strains due to viral evolution, antigenic drift, and population immunity.

Month-wise distribution of influenza-positive cases over three consecutive seasons (2022–2025) demonstrated a distinct and consistent seasonal pattern, with Influenza B activity commencing from February and continued till May, however Influenza A activity started in December and continued till March. meta-analysis study by Tamerius et al. emphasized that humidity, temperature, and population behaviour play crucial roles in seasonal influenza transmission, further explaining the low activity observed in warmer months.[10] A study by Caini et al. (2019), analysing over a decade of global influenza data, concluded that Influenza B Victoria tends to co-circulate or dominate in years when A/H1N1 is suppressed, often due to herd immunity from prior outbreaks or vaccine-induced immunity, as likely occurred following the strong H1N1 activity in 2023–2024.[11]

Age-wise distribution of Influenza B Victoria lineage cases from 2022–2025 illustrated >1–5 years age group being the most consistently affected across all three years. In 2022–2023, out of 49 total B Victoria cases, 25 (51.0%) occurred in the >1–5 years group and once again in 2024-25, highest prevalence was seen in the >1–5 years age group (25 out of 48 cases, 52.1%). However in 2023-24 with predominant Influenza subtype being Influenza A H1N1 pdm09, the most affected age group was >35-60 years with 23 (32,4%) out of 71 cases. Importantly, the second most affected age group was >1-5 years with 20 (28%) out of 71 cases. Our observations are in congruence with the findings by Lafond et al where they performed meta-analysis of 37 hospital-based influenza surveillance datasets. They concluded that maximum hospitalisations due to Influenza infection occurred in the age groups <5 years accounting to around 8,70,000 hospitalisations (24% of total hospitalisations).[12] Chadha et al reported that the highest number of ILI/SARI cases were from the age group of <5year old (n=6462), of which 276 (4·3%) were positive for Influenza infection.[,13]

We reported a higher prevalence of Influenza infection in males as compared to females. The same male preponderance was reported by Chadha et al where they reported male to female infectivity ratio as 2:1.[13] However, in a study conducted by Rafeek et al. in 2016-17, in Influenza A infections, male to female ratio was 1:1 (10:10 cases) however in Influenza B infection cases, male to female ratio was 1.5:1 (15:10 cases).[14]

We observed a statistically significant difference in influenza positivity between Influenza-like Illness (ILI) and Severe Acute Respiratory Infection (SARI) cases. Of the 797 total patients, 218 (27.4%) tested positive for influenza viruses. Among these, 42 (16.6%) were from the ILI group and 176 (32.4%) from the SARI group. The odds of testing positive for influenza were 2.40 times higher in SARI cases compared to ILI cases (OR = 2.40; 95% CI: 1.65–3.49; $p < 0.001$), indicating a highly significant association between severe clinical presentation and influenza infection. Paget et al. (2019) noted that influenza is responsible for a substantial proportion of hospitalizations globally, particularly during severe Influenza A dominant seasons. They compiled influenza-associated mortality estimates for 31 countries representing during 2002-2011. They estimated that an average of 3,89,000 deaths were associated with influenza globally each year during 2017, corresponding to approximately 2% of all annual respiratory deaths. Of these Influenza-associated deaths, 67% were among from the age group >65 years. The predominant subtype responsible for these deaths is Influenza A H1N1pdm09 subtype.[15]

5. CONCLUSION

This three-year surveillance reveals:

- Fluctuating subtype prevalence (notably H1N1pdm09 and B Victoria)
- Persistent paediatric burden (especially >1–5 years)
- Male predominance in infection rates
- Significant SARI association with Influenza subtypes
- Higher rural positivity

The study reinforces following points from observations of the Influenza trends over the past 3 years. Important steps need to be implemented in order to curtail the morbidity and mortality by Influenza infections:

1. Intensive public awareness regarding Influenza signs and symptoms throughout the year especially before seasonal flu months i.e., June-July for monsoon and post-monsoon flu season and October-November for winters and Jan-Feb for Influenza B infection).
2. Influenza Immunization drive for children less than 5 years of age with seasonal trivalent vaccines developed for that particular year and region.
3. Active Influenza surveillance to identify ILIs and suggesting appropriate treatment after testing.
4. Special Influenza clinics for children and adults to be established in hospitals during the flu seasons for testing and treating Influenza cases. It has been observed if anti-influenza treatment is started within 72 hours of start of symptoms, the morbidity and duration of illness is significantly reduced.

Use of multiplex real time PCR testing with respiratory panels detecting various viral and bacterial respiratory pathogens for appropriately detecting and treating the patients.

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