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Short communication

Demographic analysis of prevalence trends in COVID-19, Influenza, and RSV by age, sex, and race

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A R T I C L E I N F O

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A B S T R A C T

Objectives: We aimed to visualize CDC data to identify trends in respiratory illnesses—COVID-19, influenza, and RSV—across sex, age, and racial demographics, while advancing concepts of data-driven public health interventions.
Methods: We conducted a demographic analysis of CDC emergency department surveillance data (July 2023-June 2024) using Python-based visualizations developed collaboratively with generative AI. Our approach stratified COVID-19, influenza, and RSV visit percentages by sex, age group, and race/ethnicity to identify temporal patterns and high-risk populations across respiratory conditions.
Results: Analysis indicated no significant sex differences in visit rates, although females showed slightly higher rates for COVID-19, while males had higher rates for RSV. Age trends highlighted the highest visit rates for COVID-19 among young children (0−4) and the elderly (65+), influenza predominantly affecting children (0−4 and 5−17), and RSV primarily occurring in very young children (0−4). Racial disparities were observed, with Asian individuals exhibiting higher COVID-19 visit rates, while Hispanic individuals reported elevated rates for influenza and RSV.
Conclusions: Findings underscore the need for targeted public health interventions tailored to demographic-specific vulnerabilities, particularly for high-risk age groups and racial/ethnic communities disproportionately impacted by respiratory illnesses. Recommendations include culturally appropriate vaccination campaigns for Hispanic communities and specialized respiratory care for young children. This illustrates the potential of generative AI in enhancing analytical capabilities within public health, enabling a more nuanced understanding of respiratory illness trends and informing equitable health strategies that address systemic disparities across diverse populations. By integrating advanced data analytics, public health efforts can be more effectively aligned with demographic needs, ultimately working toward a healthier and more equitable society.

What is known

The prevalence and impact of respiratory diseases such as COVID-19, influenza, and RSV present significant public health challenges, particularly among vulnerable populations defined by age, sex, and race. Previous studies indicate a need for targeted interventions to improve health outcomes and reduce healthcare burdens associated with these illnesses. Existing literature highlights demographic disparities in respiratory disease prevalence and emphasizes the importance of tailored preventive measures.

What this adds

This study leverages CDC datasets to analyze and visualize trends in COVID-19, influenza, and RSV across different demographic factors. By employing generative AI to develop Python code for data visualization, it provides insights into high visit rates among specific age groups and racial demographics. The findings identify vulnerable groups—such as children aged 0−4 and older adults aged 65+—and highlight the need for early intervention. This research not only enhances the understanding of demographic patterns in respiratory disease prevalence but also democratizes access to health data analysis by enabling non-technical users to engage with important public health issues.

Introduction

Respiratory viral illnesses such as COVID-19, influenza, and respiratory syncytial virus (RSV) remain major drivers of acute-care utilization and preventable morbidity, with impacts that are not evenly distributed across populations. In translational respiratory medicine and public health, integrating demographic characteristics—particularly sex, age, and race/ethnicity—into routine surveillance is increasingly important because these factors can shape exposure risk, baseline vulnerability, healthcare access, and clinical outcomes. A demographically stratified

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view of respiratory illness trends can therefore support earlier identification of high-risk groups, more efficient allocation of limited resources (e.g., outreach, testing, vaccination, pediatric capacity), and the design of interventions that are better matched to community needs, especially in aging populations.

Recent literature underscores both progress and persistent inequities in respiratory health. In the United States, mortality from chronic lower respiratory disease (CLRD) has decreased with advances in prevention, diagnosis, and treatment, yet meaningful demographic and regional differences remain, including higher mortality in non-Hispanic White populations and rural areas and sex-specific trend differences over time [1]. Occupational and environmental risks continue to contribute to respiratory disease burden; exposure to metals such as nickel, chromium, and cobalt has been linked to work-related respiratory disease, with trends suggesting that improved workplace conditions can reduce incidence but do not eliminate risk [2]. More broadly, respiratory health is a global priority, and rapid advances in medical knowledge can leave gaps in implementation and raise ethical challenges—reinforcing the need for collaboration, knowledge sharing, and deliberate attention to disparities across demographic groups [3]. Early-life and social determinants are also pivotal: respiratory symptoms in children may signal long-term consequences, and adverse exposures from preconception through early childhood can influence lifelong respiratory health, highlighting the importance of addressing pollution, access to medications, and other structural determinants of health [4]. In addition, the post-pandemic landscape continues to evolve; evidence indicates that individuals with prior COVID-19 face increased risks for subsequent respiratory conditions, emphasizing the need for ongoing monitoring and follow-up strategies [5]. Finally, respiratory tract infections (RTIs) impose substantial global burden, with notable seasonality and co-infection patterns in healthcare settings, strengthening the case for improved prevention and timely, data-informed responses during peaks of transmission [6].

Within this context, surveillance that is explicitly stratified by demographic variables is essential for moving beyond "average" trends that may obscure disproportionate impacts. Understanding which age groups experience the highest visit rates, whether patterns differ by sex, and whether disparities are evident across racial/ethnic groups can help public health agencies and healthcare systems plan targeted mitigation strategies. These may include community-appropriate vaccination and communication campaigns, age-tailored clinical guidance (e.g., for young children and older adults), and operational planning for expected surges. Such demographic intelligence is particularly relevant when healthcare systems face competing respiratory threats in the same season and must prioritize interventions that reduce both overall burden and inequities.

Accordingly, the proposed study visualizes trends in COVID-19, influenza, and RSV using CDC data from July 15, 2023, to June 29, 2024, stratified by sex, age, and race/ethnicity [7]. The study aims to (i) characterize temporal patterns in visit rates for each illness, (ii) identify demographic groups with consistently higher rates or notable peaks, and (iii) provide a clear, reproducible analytic workflow that supports interpretation by clinicians, public health practitioners, and researchers. In addition to its epidemiologic contribution, the study leverages generative AI to assist with coding and visualization, lowering technical barriers for novice programmers and non-technical users. By demonstrating how generative AI can be used to generate Python code for transparent, reproducible plots and summaries, this work supports broader participation in public health analytics and encourages more stakeholders to engage with data-driven approaches to respiratory disease surveillance and equity-focused decision-making.

Methods

The CDC dataset contains National Syndromic Surveillance Program (NSSP) Emergency Department Visits data tracking COVID-19, influenza, RSV, and combined respiratory illness cases across various demographic categories in the United States. This comprehensive dataset comprises 11,328 records with 6 variables, covering the period from October 1, 2022, to February 14, 2026 [7]. Download the dataset and rename it to data.csv for further analysis.

We conducted visualizing pathogen visits using Python (version 3.8) with pandas (version 1.3.5) for data manipulation and matplotlib (version 3.5.1) for visualization. The analysis began with loading visit data from a structured CSV file containing information on pathogen types, demographic categories, and visit percentages over time. After loading the dataset, we implemented an interactive selection system allowing for specific pathogen isolation from the complete set of unique pathogens available in the data.

Once a pathogen was selected, the data was filtered to include only records associated with that specific pathogen. We then provided an option to select one or more demographic types (such as Sex, Age Group, or Race/Ethnicity) for further analysis. The demographic values were predefined in a dictionary structure, with Sex including Male and Female categories; Age Group divided into 65+ years, 18−64 years, 5−17 years, and 0−4 years; and Race/Ethnicity comprising Hispanic, White non-Hispanic, Asian/NHOPI non-Hispanic, and Black non-Hispanic classifications. Based on the demographic types selected, the relevant demographic values were automatically included in the analysis.

The temporal data was processed by converting the week_end field to datetime format and sorting chronologically to ensure proper time-series visualization. We then generated line plots using matplotlib, with each demographic value represented by a distinct line style (solid, dashed, dash-dot, or dotted) while maintaining a consistent black color to enhance readability and accessibility. The x-axis displayed the week end dates, while the y-axis showed the percentage of visits attributed to the selected pathogen. To improve readability of the time axis, we limited the display to a maximum of 15 date labels and rotated them 90 degrees. The resulting visualization was saved as a high-resolution PNG file (300 DPI) with a filename incorporating both the selected pathogen and demographic types, with any forward slashes in demographic type names replaced by underscores to ensure filename compatibility across operating systems.

The following is the initial query fed to generative AI using Copilot. Python code was verified by expert programmers.

Initial Query: Using the data from data.csv, plot 'percent_visits' on the Y-axis, which represents real numbers, and 'week_end' on the X-axis, which is expressed in the format "2023/07/15". Display the unique values of the pathogen column and allow the user to select one by its corresponding number. Then, show the unique values of 'demographics_type' column for the selected pathogen, and allow the user to select multiple items by their corresponding numbers, separated by spaces. If "Sex" is selected in demographics_type, display two lines for "Male" and "Female" in the demographics_values. If "Age Group" is selected in demographics_type, display four lines for "65+ years", "18−64 years", "5−17 years", and "0−4 years" in the demographics_values. If "Race/Ethnicity" is selected in demographics_type, display four lines for "Hispanic", "White, NH", "Asian/NHOPI, NH", and "Black, NH" in the 'demographics_values'. Finally, provide Python code to draw multiple lines with four different linestyles and black colored.

It is important to remember that multiple conversations or iterations and user verification of Python code are crucial to achieving successful and desired outcomes due to the inherent imperfections of generative AI.

Results

We developed reproducible visualization code that is publicly available on GitHub [8]. Figs. 1−3 present the percentage of emergency department visits attributed to COVID-19, influenza, and RSV across three demographic categories: sex (Fig. 1−1, 2−1, 3−1), age groups (Fig. 1−2, 2−2, 3−2), and race/ethnicity (Fig. 1−3, 2−3, 3−3). Each

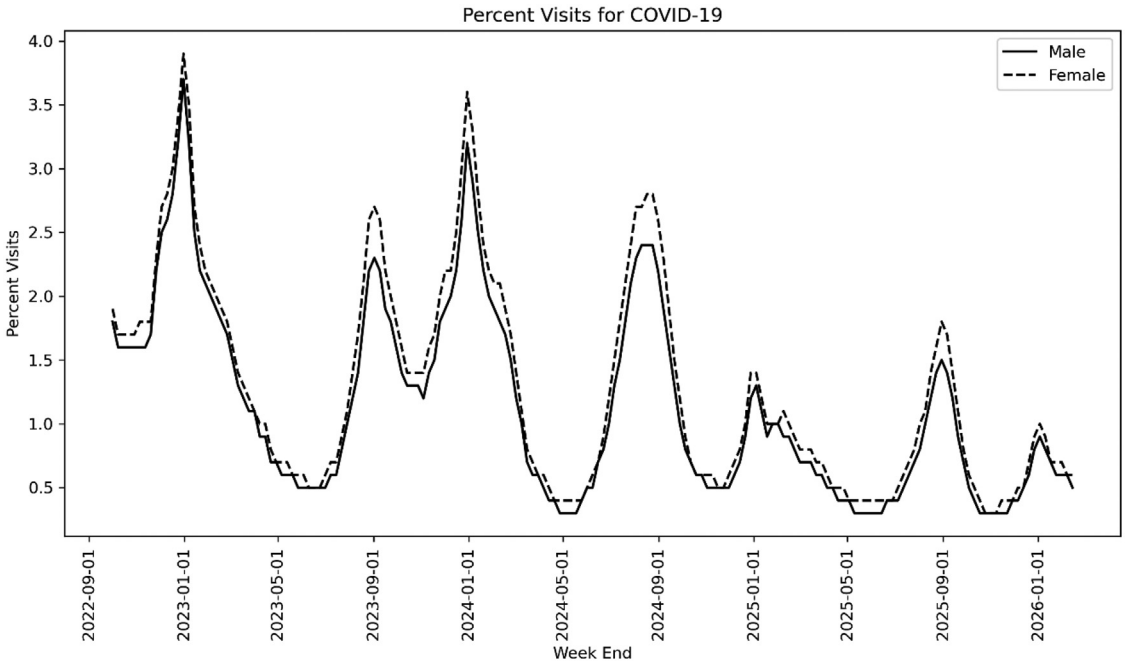

Fig. 1−1. COVID-19 percent visits by sex.

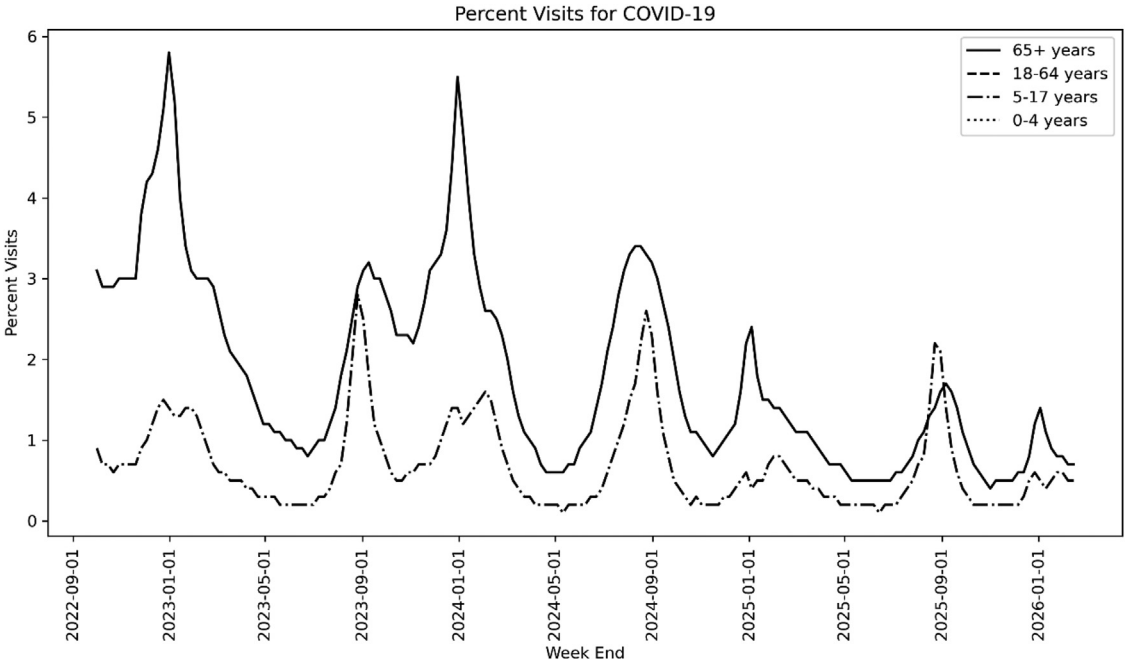

Fig. 1−2. COVID-19 percent visits by age.

visualization reveals distinct temporal and demographic patterns in respiratory disease burden.

COVID-19 patterns

As shown in Fig. 1−1, COVID-19 visits displayed recurring wave-like fluctuations from late 2022 through early 2026, with gradual decline toward recent dates. Male and female patients followed nearly identical temporal patterns, with females showing slightly higher visit percentages during most peak periods.

Fig. 1−2 reveals substantial variation across age groups, with adults aged 65+ consistently showing the highest visit percentages, followed by adults 18−64 years. Children (0−4 and 5−17 years) experienced comparatively smaller fluctuations. Despite these differences in magnitude, all age groups displayed synchronous patterns.

In Fig. 1−3, Hispanic individuals consistently demonstrated the highest COVID-19 visit percentages during major surges, followed by non-Hispanic White patients. Non-Hispanic Asian/NHOPI and non-Hispanic Black individuals experienced comparatively smaller fluctuations, though all racial and ethnic groups displayed parallel trends over time.

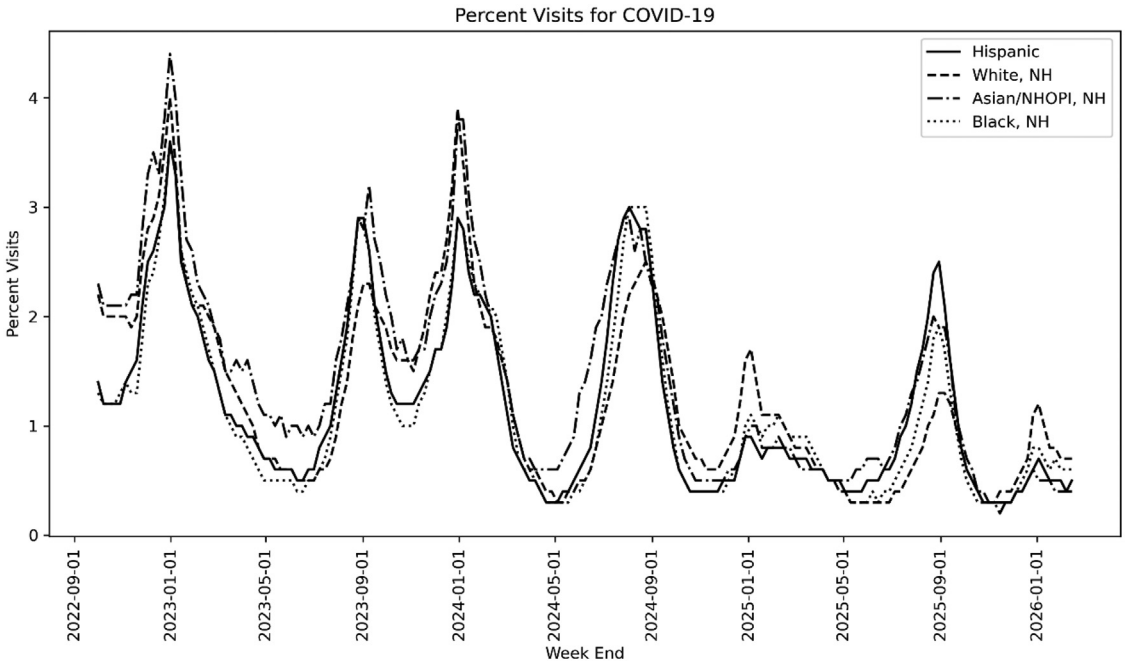

Fig. 1−3. COVID-19 percent visits by race.

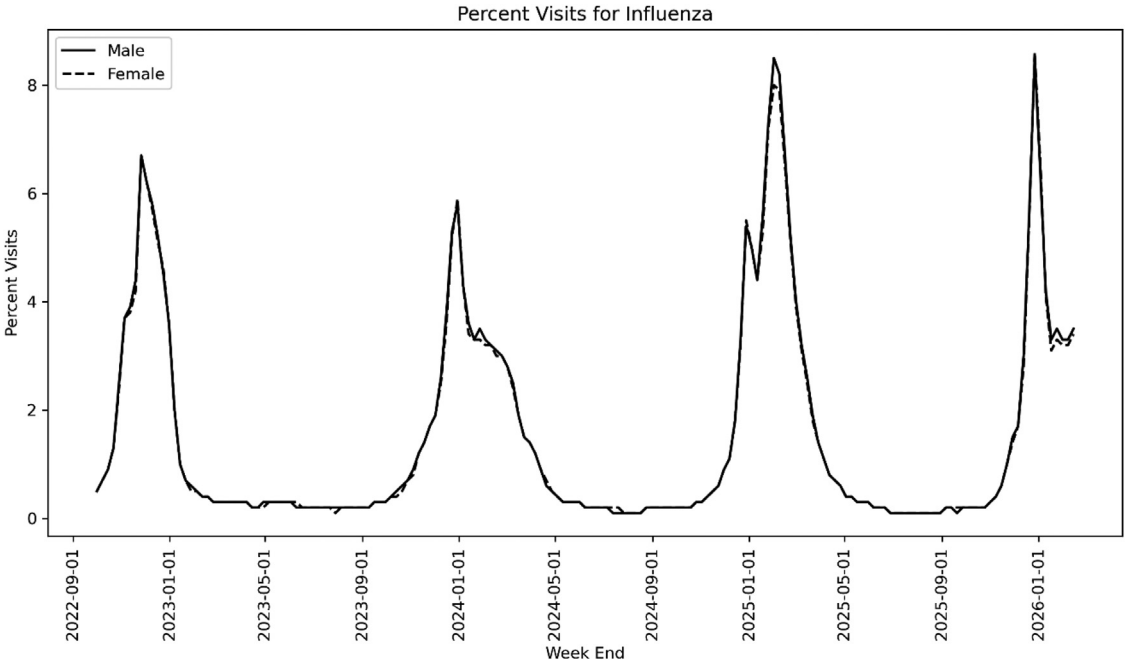

Fig. 2−1. Influenza percent visits by sex.

Influenza patterns

Fig. 2−1 shows clear seasonal influenza patterns with pronounced peaks around the beginning of each year. Male and female patients exhibited highly similar trajectories, with females occasionally showing slightly higher peak visit percentages.

In Fig. 2−2, children aged 5−17 years consistently exhibited the highest influenza visit percentages, followed closely by those aged 0−4 years. Adults showed more moderate fluctuations, with those 65+ experiencing the lowest peaks among all age groups.

Fig. 2−3 demonstrates that Hispanic individuals consistently had the highest influenza visit percentages, followed by non-Hispanic White patients. Non-Hispanic Asian/NHOPI and non-Hispanic Black individuals showed smaller but synchronized seasonal fluctuations.

RSV patterns

As shown in Fig. 3−1, RSV visits displayed clear seasonal peaks, with males showing slightly higher percentages than females during peak periods.

Fig. 3−2 reveals that children aged 0−4 years consistently exhibited substantially higher RSV visit percentages than all other age groups. Individuals aged 5−17 years showed smaller but distinct seasonal increases, while adults experienced comparatively low fluctuations.

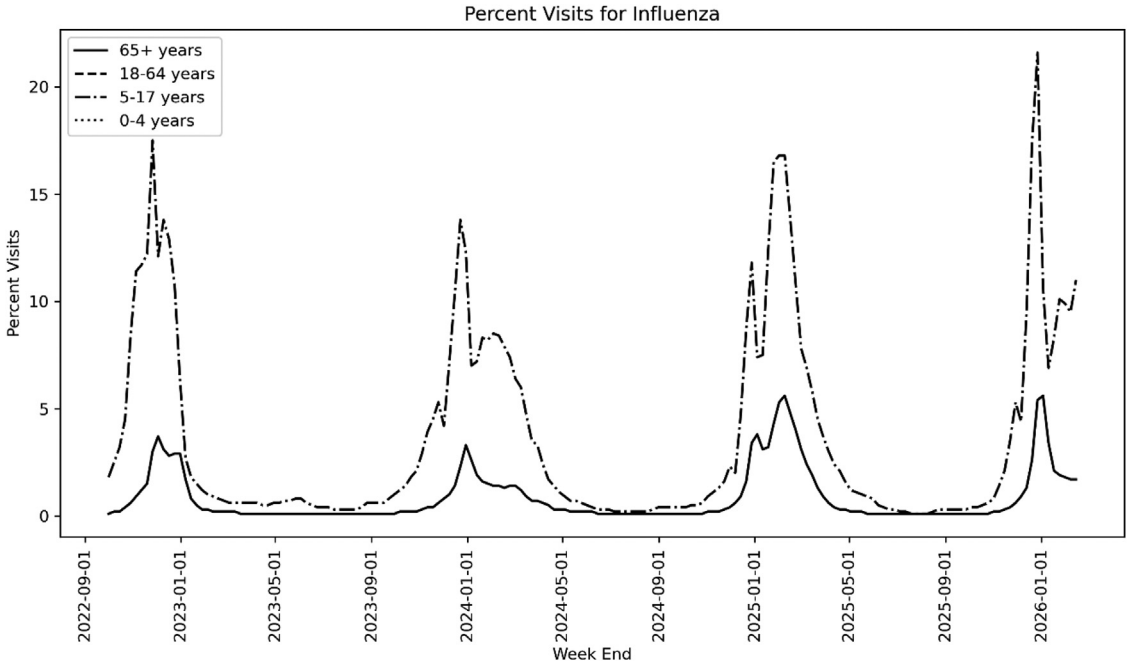

Fig. 2−2. Influenza percent visits by age.

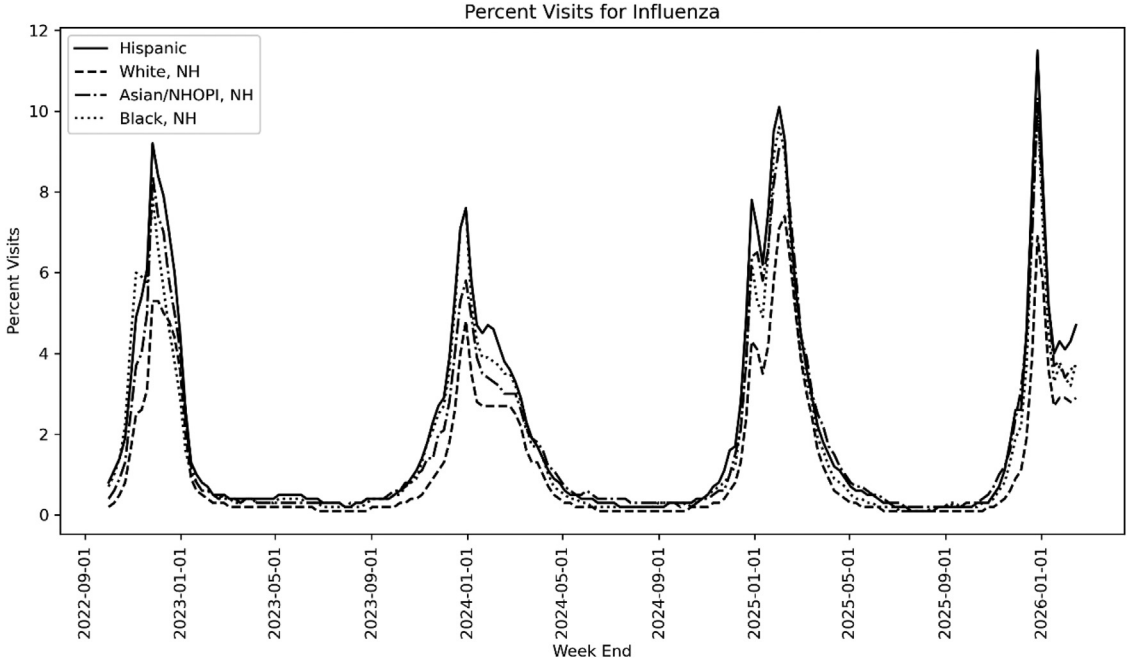

Fig. 2−3. Influenza percent visits by race.

Fig. 3−3 demonstrates that Hispanic individuals consistently had the highest RSV visit percentages across all racial and ethnic groups, followed by non-Hispanic White patients. All groups showed synchronized seasonal patterns with modest reduction in peak intensity toward recent dates.

Discussion

The analysis of visit percentages for COVID-19, influenza, and RSV across various demographics reveals several notable trends that advance our understanding of population health dynamics, combining data-driven insights with public health applications. While overall differences between males and females are not statistically significant, nuanced observations emerge: females demonstrate a slightly higher percentage of visits for COVID-19, suggesting variations in health-seeking behavior or potential susceptibility. Conversely, males exhibit higher percentages for RSV, marked by two significant peaks, which underscores the necessity for targeted education and outreach initiatives tailored to this demographic's specific health challenges. This highlights a conceptual advancement in recognizing the multifaceted influences of sex on health

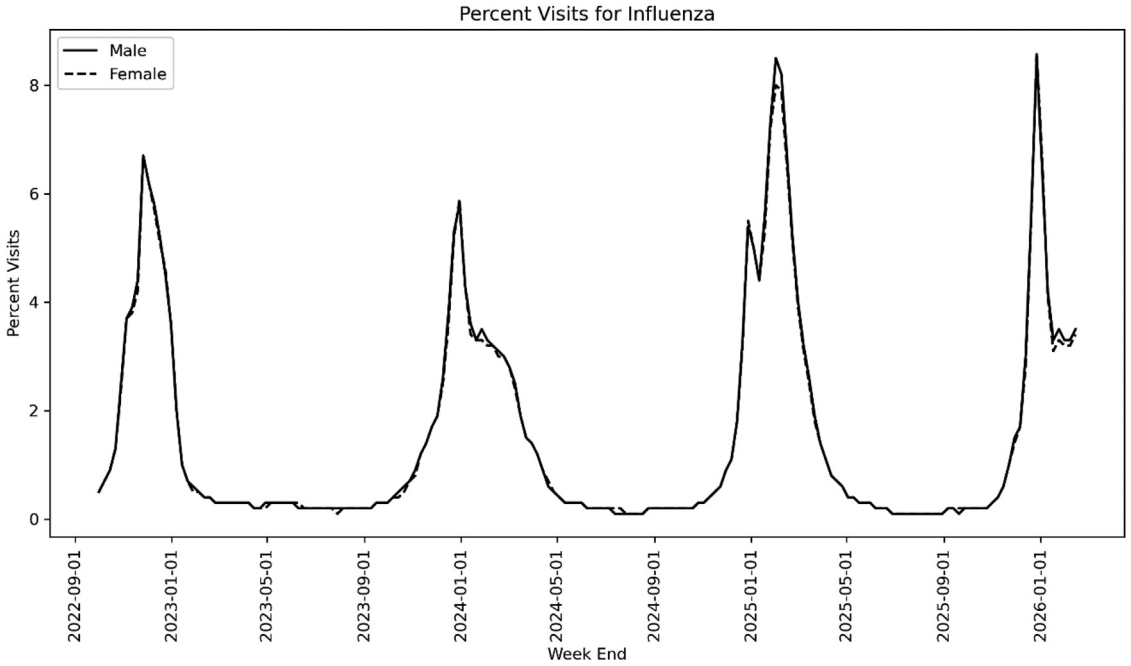

Fig. 3−1. RSV percent visits by sex.

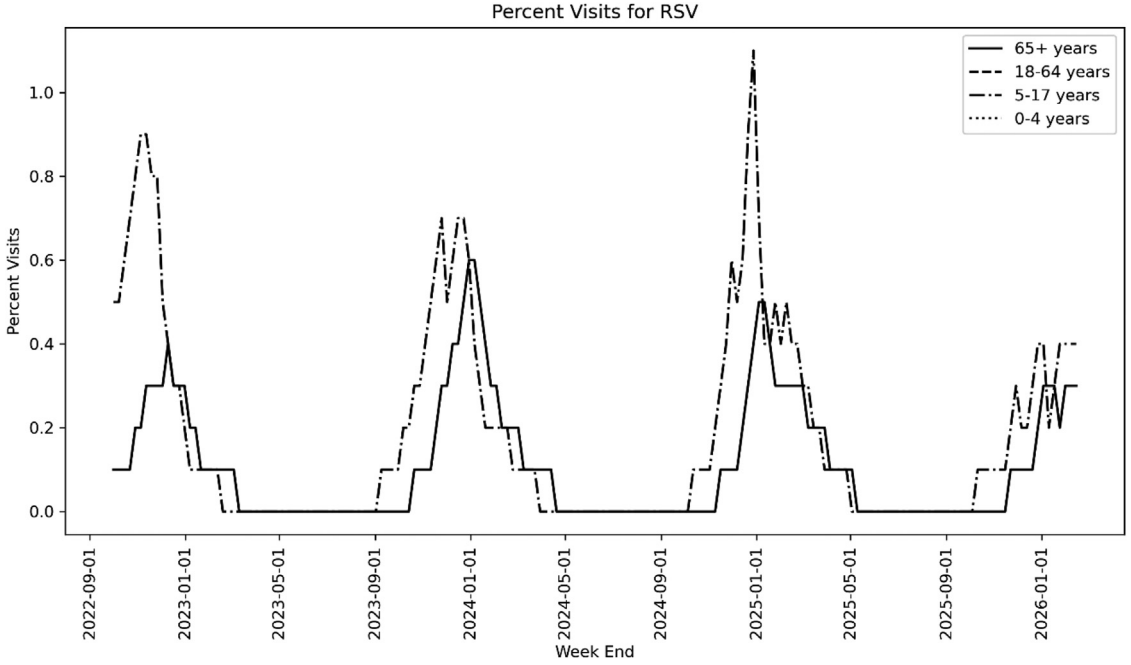

Fig. 3−2. RSV percent visits by age.

outcomes, emphasizing the importance of sex-sensitive public health interventions.

Age analysis further enriches this conceptual framework, indicating that both the 0−4 years and 65+ years age groups present the highest percentages of visits for COVID-19. This finding reinforces established insights regarding the heightened vulnerability of these populations and underscores the critical need for robust prevention strategies targeted specifically at these groups. The data on influenza and RSV confirms the significant impact on the very young, especially those aged 0−4, warranting urgent attention to preventive measures in pediatric care. Racial disparities introduce an additional layer of complexity, noting higher visit rates for COVID-19 among Asian individuals, which may reflect underlying issues such as socioeconomic status, healthcare access, and cultural perceptions of illness. Hispanic communities also demonstrate increased visit percentages for both influenza and RSV, suggesting unique exposures and systemic challenges that must be urgently addressed.

These findings underline the pressing need for tailored public health interventions that are responsive to sex, age, and racial differences, enabling the development of effective prevention and treatment

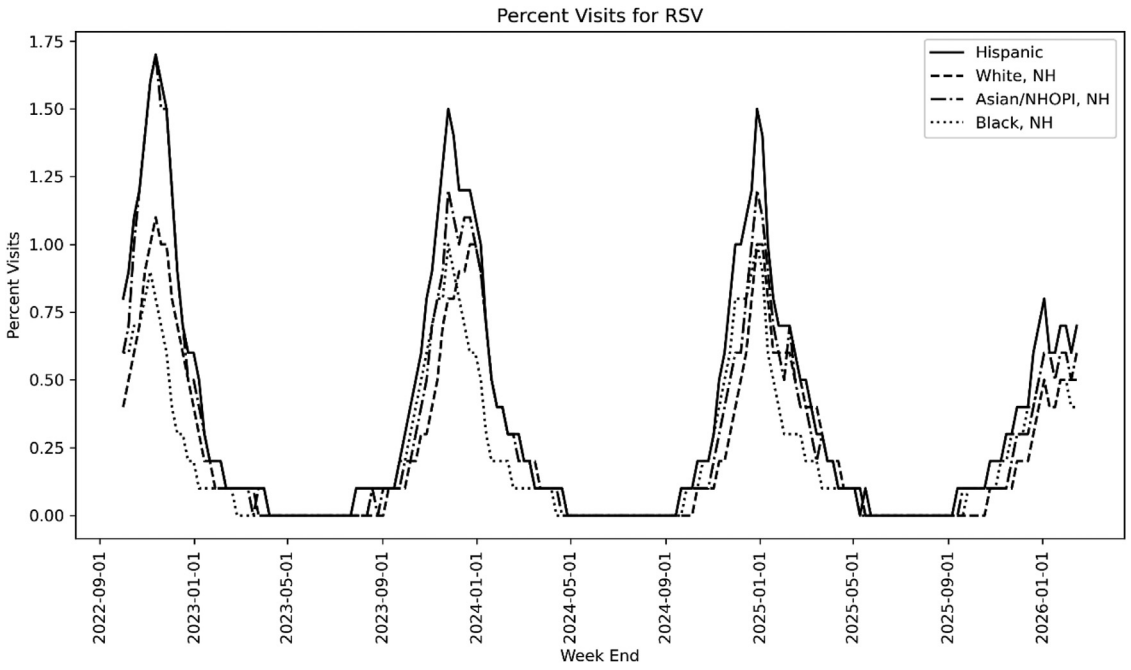

Fig. 3−3. RSV percent visits by race.

strategies that are culturally appropriate and accessible. By adopting a translational medicine perspective, focused interventions targeting individuals aged 65 and older for COVID-19 are particularly crucial given their significant risks and barriers to care. Integrating these demographic insights into public health planning not only informs more responsive and effective strategies but also advances the field of public health by fostering a deeper comprehension of how social determinants of health intersect with disease prevalence. Through such targeted approaches, we can aim to mitigate the impacts of respiratory illnesses across diverse population segments, ultimately enhancing health equity and improving overall community health outcomes.

Several important limitations should be considered when interpreting these visualizations. First, our analysis encompasses a one-year time frame, which may not capture long-term trends or multiple cycles of disease transmission patterns. This limited temporal window presents only a snapshot of respiratory disease burden rather than establishing sustained patterns across multiple seasons.

Second, respiratory illnesses demonstrate strong seasonality effects, and our visualization captures only one seasonal cycle. The patterns observed may not represent typical seasonal variations, particularly given the disrupted respiratory virus circulation patterns in recent years following the COVID-19 pandemic.

Third, while our visualization approach avoids analytical biases associated with statistical modeling, the underlying syndromic surveillance data may contain inherent biases related to healthcare access, care-seeking behaviors that vary across demographic groups, and geographic heterogeneity in ED utilization and reporting practices.

Finally, changes in testing availability, clinical awareness, and diagnostic coding practices during the study period may influence apparent disease patterns independent of true epidemiological trends.

Conclusion

Our visualization of COVID-19, influenza, and RSV emergency department visit patterns reveals significant demographic variations with important implications for public health practice. The stratified analysis demonstrates that respiratory disease burden is unequally distributed across population groups, with consistent patterns emerging across the three pathogens studied. Hispanic individuals consistently experienced higher visit percentages for all three respiratory conditions, potentially reflecting complex interactions between exposure risk, healthcare access, and underlying health status. Among age groups, the highest-risk populations varied by pathogen: adults 65+ for COVID-19, school-age children (5−17 years) for influenza, and young children (0−4 years) for RSV. These findings align with known biological vulnerability factors but also highlight opportunities for targeted intervention.

The synchronized temporal patterns across demographic groups, with simultaneous rises and falls despite differences in magnitude, suggest common transmission dynamics influenced by seasonal factors, population mixing, and viral characteristics. This synchronicity has implications for healthcare capacity planning, as surges will affect multiple demographic groups concurrently even when absolute burden differs substantially. Our finding that sex-based differences were relatively modest compared to age and racial/ethnic variations suggests that biological sex may play a less determinative role in emergency care utilization for these conditions than social and environmental factors.

These results underscore the importance of demographically-informed approaches to respiratory disease surveillance and intervention. Public health agencies should consider developing surveillance dashboards that routinely incorporate demographic stratification to detect emerging disparities. Healthcare systems would benefit from demographic forecasting to anticipate seasonal capacity needs, particularly in pediatric settings during RSV and influenza peaks. Vaccination campaigns should prioritize highest-risk groups while addressing potential access barriers for Hispanic communities. Future research should explore the underlying mechanisms of these disparities, including the roles of household structure, occupation, healthcare access, and environmental exposures.

By leveraging generative AI to create reproducible visualization code, we have demonstrated an approach that can be adapted for ongoing surveillance and expanded to additional demographic intersections or geographic regions. This work represents a step toward more equitable respiratory disease monitoring and intervention in an era of multiple concurrent respiratory threats.

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Ethics approval

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Consent to participate

Not applicable.

Consent for publication

Not applicable.

Human and animal right

Not applicable.

Availability of data and material

The author has no permission to share data.

Code availability

Python code is provided in the manuscript.

Authors' contributions

Yoshiyasu Takefuji completed this research and wrote the program and this article.

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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Not applicable.

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