

## Original Article

**Analysis of epidemiological characteristics of influenza in Qingdao, China during 2019-2023**Yu Gao<sup>1#</sup>, Chunhui Wang<sup>2#</sup>, Ying Li<sup>3</sup>, Jinru Li<sup>1</sup>, Jingfei Zhang<sup>1</sup>, Zhaohai Meng<sup>4#</sup>, Jing Jia<sup>1#</sup><sup>1</sup> Department of Acute Infectious Disease, Qingdao Municipal Center for Disease Control and Prevention, Qingdao Institute of Prevention Medicine, Qingdao, Shinan District, Shandong Province, China 266071<sup>2</sup> Qingdao Shibe Districts Center for Disease Control and Prevention, Qingdao, Shibe District, Shandong Province, China 266011<sup>3</sup> Institute for Viral Disease Control and Prevention, China Center for Disease Control and Prevention, Beijing, China 102206<sup>4</sup> Qingdao West Coast New Area Center for Disease Control and Prevention, Qingdao, Huangdao District, Shandong Province, China 266400

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**Abstract**

**Introduction:** Influenza is a respiratory infectious disease that seriously affects public health. Currently, there is lack of study on spatial-temporal and seasonal analysis of data for nearly five years. This study aimed to investigate the epidemiological characteristics of influenza in Qingdao City, China, from 2019 to 2023, to contribute towards public health and disease control interventions.

**Methodology:** The annual influenza incidence rate of the city was visualized in streets and towns. Spatial autocorrelation analysis and spatial-temporal analysis were performed to measure the cluster effect on spatial distribution and temporal trends. Seasonal trend analysis was used to describe the seasonal distribution of influenza. Etiology analysis of the influenza virus displayed an altered trend of positive rates and subtypes. **Results:** Positive spatial autocorrelation was detected on urban and coastal streets, except in 2021. A possible spatial-temporal cluster was discovered in November 2023 that was located in urban and coastal streets. There was a major peak in winter and small fluctuations formed the seasonal epidemic trend of influenza incidence in Qingdao. Etiology analysis revealed that the positive rate of influenza virus usually peaks from January to March. Influenza A virus (H1N1 and H3N2) and influenza B virus (Victoria lineage) alternatively or jointly spread in the five years, and influenza A virus was the dominant type.

**Conclusions:** This study identified the epidemic characteristics of influenza in Qingdao City in the five years. Further research on environmental factors and etiological characteristics is recommended to help explore the epidemic patterns of outbreaks and aggregation of influenza.

**Key words:** epidemiology; influenza; spatial-temporal distribution; spatial analysis; Qingdao.*J Infect Dev Ctries* 2025; 19(11):1711-1717. doi:10.3855/jidc.20180

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Copyright © 2025 Gao *et al.* This is an open-access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.**Introduction**

Influenza is a respiratory infectious disease that has serious impact on public health. Seasonal influenza may cause 290,000 to 650,000 deaths each year due to respiratory diseases alone [1]. The high rates of hospitalizations and deaths due to influenza contribute to the heavy burden of the disease [2,3], especially for children and the elderly [4–6]. Furthermore, influenza in pregnant women is associated with increased risk of fetal death [7]. Most research studies suggest that influenza-related complications that include the cardiovascular, circulatory, and nervous systems are the leading cause of mortality associated with the disease [8–11].

Previous studies have shown that the spread of

influenza is affected by a multitude factors, such as the virus spread characteristics, climate, and environment [12–14]. In temperate regions, influenza generally presents as seasonal epidemics, and a peak is usually observed in the winter. In tropical and subtropical regions, influenza can occur at different times of the year. Investigation of the epidemiological characteristics in the locality can help offer a basis for public health interventions to slow down or control the spread of influenza, and ultimately reduce the probability of pandemics, epidemics, and small outbreaks.

There is lack of studies on spatial-temporal and seasonal analysis of influenza using data from at least five years. This study aimed to analyze the

epidemiological characteristics of influenza in Qingdao City from 2019 to 2023 using demographics, spatial-temporal clustering, and seasonality.

**Methodology**

*Data source*

Qingdao City is a coastal prefecture-level city in eastern China—longitude 119°30’ to 121°00’E and latitude 35°35’ to 37°09’N. Qingdao City has temperate and monsoonal climate. As of 2020, it has 4 districts and 7 county-level cities, including 145 streets or towns, covering an area of 11,293.36 km<sup>2</sup>.

The data on influenza cases during 2019 to 2023 was collected from the Chinese Disease Prevention and Control System [15], and the demographic information was obtained from the 7<sup>th</sup> National Population Census in 2020. Only influenza cases with current address in Qingdao city were included, and comprised of laboratory-confirmed cases and clinically diagnosed cases.

In China, healthcare facilities are legally required to report influenza cases. Cases with fever (body temperature > 38 °C), accompanied by cough or sore throat are defined as flu-like cases. If the throat swab or nasopharyngeal swab detects the influenza virus after nucleic acid test, then the cases are diagnosed as confirmed cases of influenza. Clinical flu-like cases with epidemiological association of confirmed cases can be diagnosed as ‘clinically diagnosed cases of influenza’, even if there is no etiology detection. Both confirmed cases and clinically diagnosed cases of influenza need to be reported to the Chinese Disease Prevention and Control System.

The sentinel surveillance data of influenza virus during 2019 to 2023 was obtained from the China Influenza Surveillance Information System [16]. The sentinel hospitals are responsible for collecting oropharyngeal swabs of flu-like cases weekly and then sending them to the laboratory for nucleic acid testing. The test results are reported in the China Influenza

Surveillance Information System.

*Statistical analyses*

Excel 2016 was used for data collection and statistical analyses. A database of influenza incidence in the streets unit was created. Annual incidence rate in all streets and towns of the city was visualized by the ArcGIS10.7 software.

Spatial aggregation analysis, including global spatial autocorrelation and local spatial autocorrelation was performed with the Geoda 1.22 software [17,18]. Moran index (Moran’I) > 0 indicated a spatial positive correlation for the disease, Moran’I = 0, indicated a random spatial distribution of the disease, and Moran’I < 0 indicated a spatial negative correlation for the disease. The closer the Moran’I was to 1 or – 1, the stronger the autocorrelation and the more pronounced the spatial clustering. Differences were considered significant if *p* < 0.05, suggesting presence of spatial clustering. Local spatial autocorrelation divided the clusters into four association patterns: "high-high", "high-low", "low-high" and "low-low".

Spatial-temporal scanning analysis was carried out with SaTScan 10.1.2 software, taking the street and town as the space unit and the monthly incidence as the clustering unit [15,18]. Scanning with the cylindrical scanning window was executed through the space time retrospective analysis model, and the discrete Poisson model scan was used in the statistical mode. The maximum cluster size was set to 50% of the population at risk, and the maximum temporal cluster size was set to 1 month of this study period. The log-likelihood ratio (LLR) was constructed with the theoretical number and the actual number, and the significance of LLR was evaluated by the Monte Carlo random method. The simulation number was set to 999. If *p* < 0.05, it demonstrated that spatiotemporal clustering existed between the incidence in the scan area and surrounding clusters. The larger the LLR and relative risk (RR) values, the higher the degree of aggregation. The

**Table 1.** Demographic characteristics of influenza cases in Qingdao City from 2019 to 2023.

Category	2019	2020	2021	2022	2023	Total
All cases	1315	875	144	389	18462	21185
Incidence (per 100,000)	13.06	8.69	1.43	3.86	183.31	210.24
Gender (n, %)						
Male	701 (53.31)	442 (50.51)	92 (63.89)	213 (54.76)	9680 (52.43)	11128 (52.53)
Female	614 (46.69)	433 (49.49)	52 (36.11)	176 (45.24)	8782 (47.57)	10057 (47.47)
Age in years (n, %)						
0–4	641 (48.75)	404 (46.17)	19 (13.19)	87 (22.37)	3129 (16.95)	4280 (20.20)
5–14	362 (27.53)	256 (29.26)	41 (28.47)	159 (40.87)	6588 (35.68)	7406 (34.96)
15–24	34 (2.59)	42 (4.80)	3 (2.08)	19 (4.88)	2214 (11.99)	2312 (10.91)
25–29	48 (3.65)	29 (3.31)	4 (2.78)	14 (3.60)	1212 (6.56)	1307 (6.17)
30–59	137 (10.42)	109 (12.46)	57 (39.58)	76 (19.54)	3023 (16.37)	3402 (16.06)
≥ 60	93 (7.07)	35 (4.00)	20 (3.89)	34 (8.74)	2296 (12.44)	2478 (11.70)

scanning window with the maximum LLR value was the first secondary cluster, and other windows with statistically significant LLR were the second secondary clusters. The cases and population data from 2020–2022 was analyzed together as continuous data, and separately in 2019 and 2023. The spatiotemporal scan results were visualized with the ArcGIS 10.7 software.

Seasonal trend analysis was performed with the R 4.3.1 software to describe the seasonal distribution of influenza. A time series was established in terms of months, and seasonal decomposition was achieved through the automatic autoregressive integrated moving average (ARIMA) model [19]. The results were presented in four components: original time series data, trend, seasonality, and random effect.

Etiology analysis was used to assess positive activity of the influenza virus. The database included the number of influenza viruses of different subtypes, and the global incidence rate in months.

**Results**

*Descriptive analysis of influenza cases*

The demographic characteristics of the influenza cases are summarized in Table 1. A total of 21,185

**Table 2.** Results of the global spatial autocorrelation analysis in Qingdao City, 2019–2023.

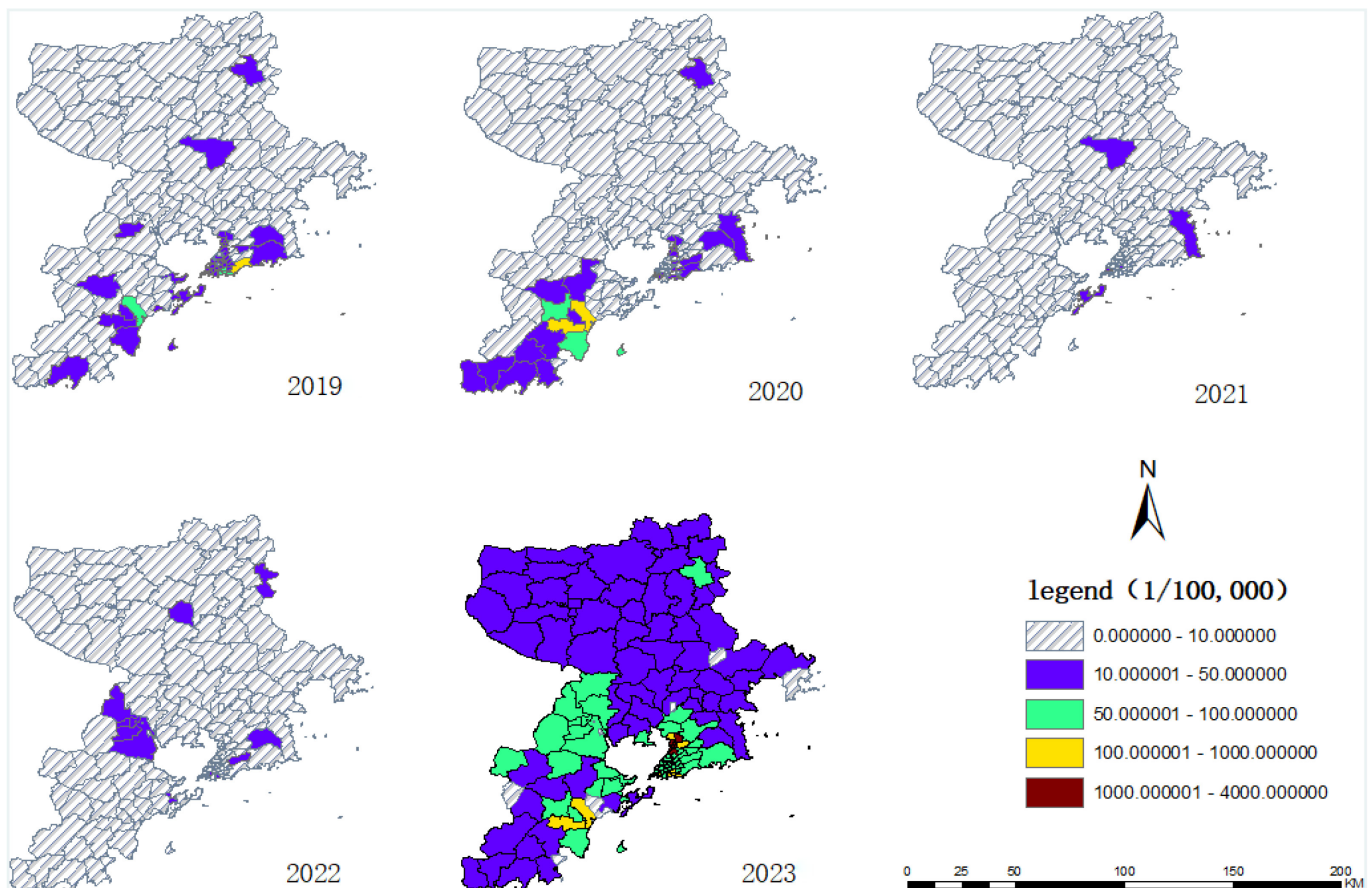
Year	Moran's I	Z value	p value
2019	0.3859	7.7408	0.001
2020	0.4789	10.2732	0.002
2021	0.0609	1.6230	0.054
2022	0.2876	6.6505	0.001
2023	0.2236	5.0632	0.005

cases were reported from 2019 to 2023, which consisted of 15,632 confirmed cases and 5,553 clinically diagnosed cases. There was less incidence in 2020–2022, than in 2019 and 2023. The incidence was generally higher in males than in females. There was a higher proportion of children aged 0–4 years and teenagers aged 5–14 years, than the other age groups. The annual incidence rate in Qingdao from 2019 to 2023 is presented in Figure 1.

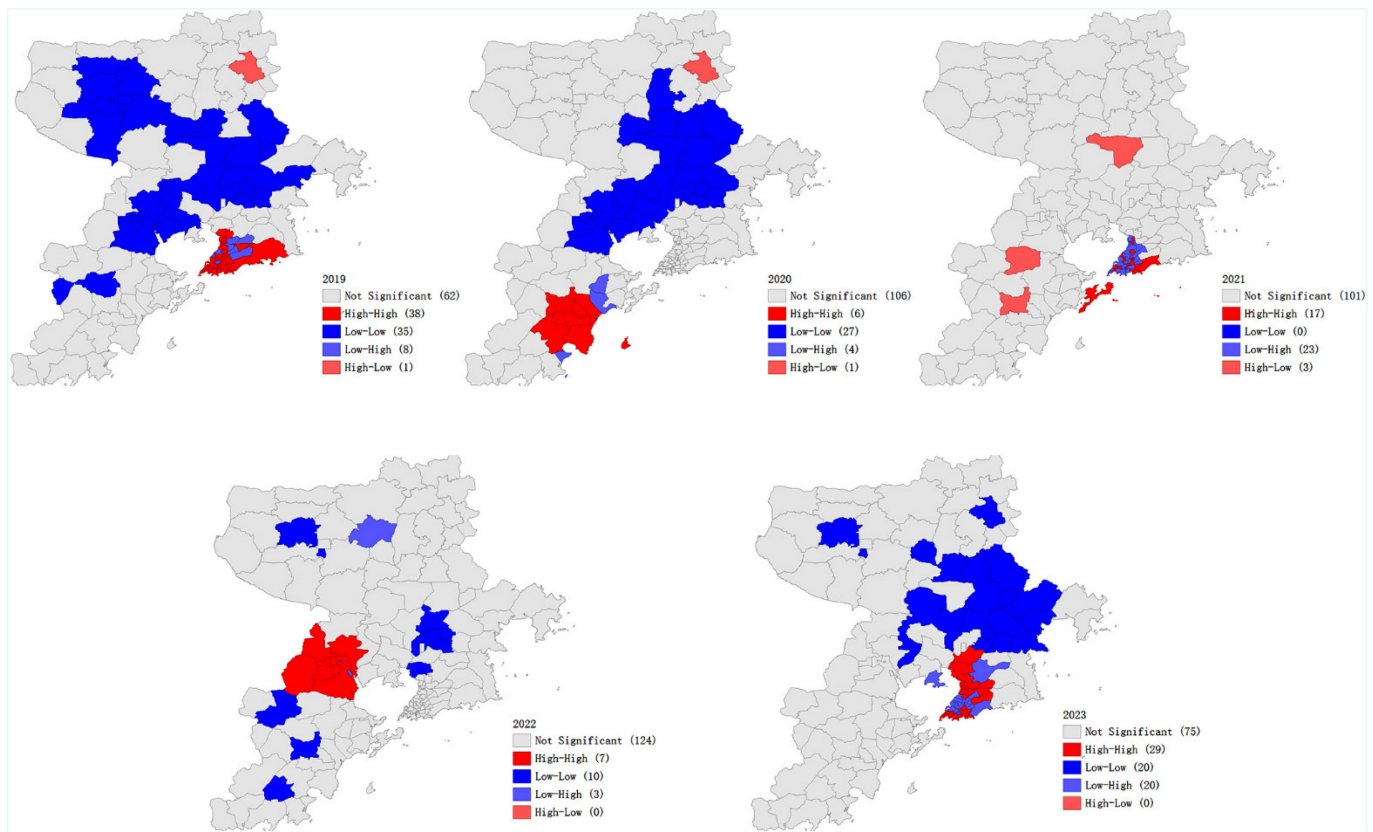
*Spatial analysis*

The global autocorrelation results are presented in Table 2. The Moran's I value was significant in all years except 2021 ( $p < 0.05$ ). Local autocorrelation analysis found 27 "high-high" clusters, in the study period. The "high-high" clusters in 2019, 2021, and 2023 were

**Figure 1.** The annual incidence rate of influenza in Qingdao City calculated with the natural breaks (Jenks) method from 2019 to 2023.



**Figure 2.** Local autocorrelation analysis of influenza from 2019 to 2023 in Qingdao City.



relatively large and mainly concentrated in urban areas (Figure 2).

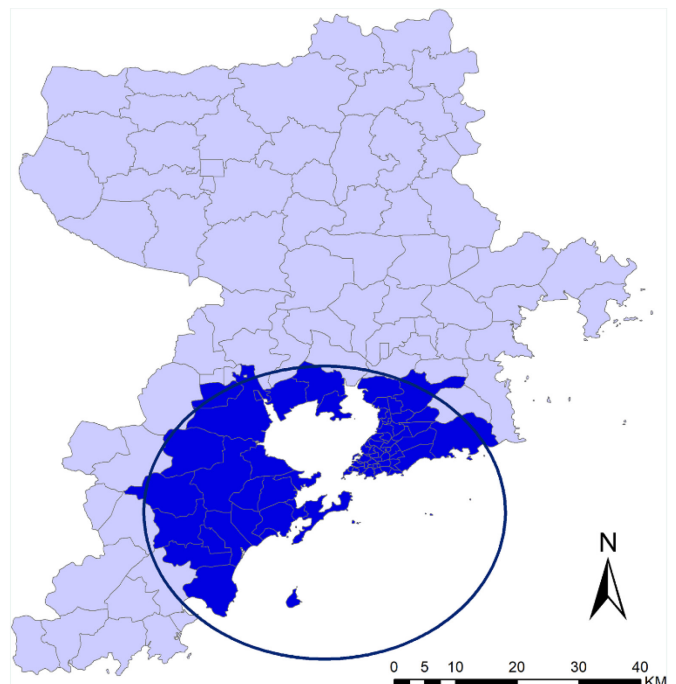
*Spatial-temporal scanning analysis*

The results of spatial-temporal scanning analysis are presented in Figure 3. The most likely clusters were identified by temporal scanning ( $p < 0.001$ ). The most likely clusters in 2023 were located in urban and coastal areas (Shinan, Shibe, Licang, Laoshan, Huangdao, Chengyang, Gaoxin, and Jiaozhou Districts), including 71 streets or towns. The cluster time ranged from 1 November to 30 November and the radius was 38.17 Km (RR: 47.85; LIR: 14409.63).

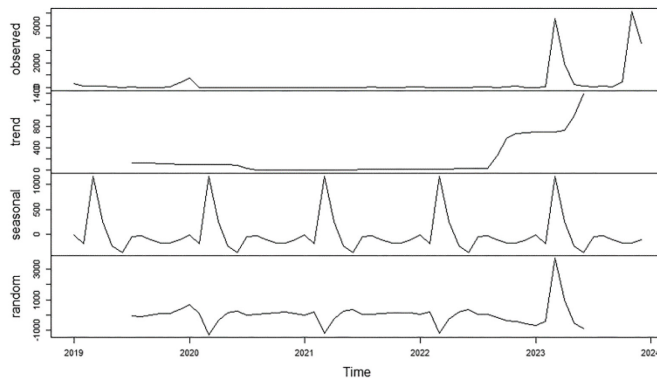
*Seasonal trend analysis*

The trends of influenza cases were low between 2019 and 2021; and increased rapidly in 2022 and 2023. Figure 4 shows that influenza cases in Qingdao City showed an obvious periodic trend. The epidemic peak in winter was noted in January to March, and there were small fluctuations in June to July, and in October to November.

**Figure 3.** Spatial-temporal scanning analysis of influenza from 2019 to 2023 in Qingdao City. One ‘most likely cluster’ was identified in 2023.



**Figure 4.** Seasonal trend analysis of influenza in Qingdao City, 2019–2023.



*Etiology analysis of influenza virus*

Figure 5 shows the influenza positive rate based on the subtype of the virus. The trend of positive rates of influenza cases were concordant with the results of the seasonal trend analysis. The positive rate usually peaked from January to March. Several different subtypes of the influenza virus alternatively or jointly spread in the five years. The influenza A virus was the dominant type, of which the subtype of H3N2 accounted for the vast majority of cases. However, only the influenza B virus (Victoria lineage) was prevalent in the winter between September 2021 and May 2022.

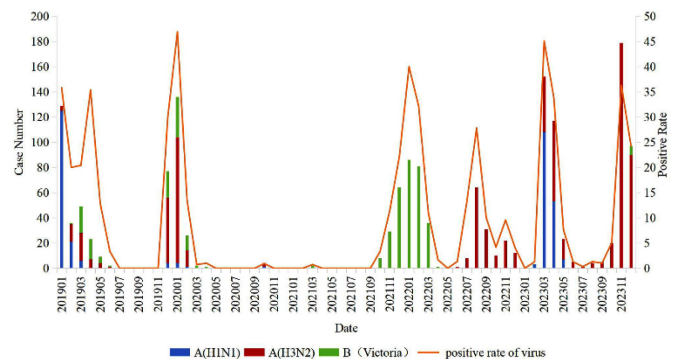
**Discussion**

In this study, the epidemiological characteristics of influenza in Qingdao City from 2019 to 2023 were analyzed. Improved understanding of the epidemic pattern of influenza would be conducive to provide basis for further prevention and control strategies and effective interventions.

The incidence rate of influenza in Qingdao City from 2019–2022 was low, and some studies [20–22] have indicated that the zero-coronavirus disease 2019 (COVID-19) strategy in China over the previous three years may have led to a decline in the incidence rate of respiratory diseases, especially influenza. While the incidence rate of influenza soared in 2023, it was reported that public health and social interventions implemented during the COVID-19 pandemic from 2019 to 2022 resulted in increased susceptibility of populations to seasonal influenza [23]. In line with previous studies [24], this study identified a high incidence rate concentrated in the groups of males and adolescents.

Global and local autocorrelation analysis at the street level found that, except in 2021, the entire Qingdao City showed significant aggregation effect in the 5 years of study and “high-high” clusters

**Figure 5.** Positive activity by influenza virus in Qingdao City, 2019–2023.



concentrated in urban and coastal streets. Moreover, there was a spatial and temporal clustering of the incidence of influenza in Qingdao City in November 2023, and the cluster mainly existed in urban and coastal streets or towns. The results of local autocorrelation and spatial-temporal analysis underscore the correlation of influenza aggregation with environmental factors [18,25,26]. Qingdao City has a temperate monsoon climate. Summer is hot and rainy, but winter is cold and dry. Temperature and relative humidity are important factors affecting influenza transmission [27,28].

Qingdao City has obvious seasonal variations, and this is the same in the cities in northern China. In such regions with seasonal variations, winter—extending from October of the current year to March of the following year—is the peak period for influenza [29,30], because of the low temperature. However, small fluctuations may appear in summer as well. Qingdao City is a tourist city, and summer is the peak for tourism. The reason for the rise in influenza incidence in summer is the increase in population flow and the increase in humidity [31].

Etiology analysis revealed that the trend of positivity rates was generally consistent with reported influenza cases, and the major peak positivity occurred in winter. In addition, the virus type causing the influenza epidemic peak was mainly influenza A virus, especially H3N2 [32]. Subtype H3N2 was detected even in the summer, resulting in influenza cases and increased positivity rates. The influenza B virus (Victoria lineage) was responsible for a prevalence peak only between September 2021 and May 2022. The influenza B virus (Victoria lineage) is considered to have a low probability of causing large pandemics [13,33], and this was in accordance with the insignificant results of the global autocorrelation analysis in 2021.

The non-pharmacological interventions during the zero-COVID-19 strategy were effective in the prevention and control of respiratory infectious diseases [20]. Popular science awareness of influenza to the public should be intensified in the disease prevention work. Following the COVID-19 pandemic period, the respiratory infectious diseases peaked in 2023. Future studies may consider consolidating prevention and control strategies and taking comprehensive intervention through multi-pathogen monitoring. Simultaneously, strengthening sentinel monitoring, timely disposal of influenza cluster, and scientific education and awareness is necessary.

There are some limitations in this study. During the clinical diagnosis of cases of influenza, it was difficult to distinguish influenza from other respiratory diseases in the absence of laboratory tests; thus, it inevitably raised the possibility of misreporting. The incidence rate of influenza was reduced with the implementation of zero-COVID-19 strategy in 2019–2022; thus, a large gap in the annual incidence rate may have led to too few clusters from spatial-temporal scanning. In addition, errors in population demographic data and incidence rates may occur due to changes in administrative divisions.

## Conclusions

This study identified the epidemic characteristics of influenza in Qingdao City, China, from 2019 to 2023, based on the demographic characteristics, temporal and spatial distribution, seasonal epidemic trends, and change in etiology. Further research on the environmental factors and etiological characteristics is recommended to help explore the epidemic pattern of outbreaks and the aggregation of the influenza virus.

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## Authors' contributions

YL, JL, JZ, research proposal and data collection; YG, CW, data analysis, manuscript writing; JJ, ZM, constructive criticisms and manuscript editing.

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## Conflict of interest

No conflict of interest is declared.

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