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# Retrospective study on the epidemiological characteristics of multi-pathogen infections of hospitalized severe acute respiratory tract infection and influenza-like illness in Xinjiang from January to May 2024

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## Abstract

**Background** Acute respiratory tract infections are very common and can be caused by many pathogens. The aim of this study was to understand the characteristics of multi-pathogen infections of respiratory tract infections during the seasonal changes in winter and spring in Xinjiang.

**Methods** Throat swab samples were collected from 2791 patients with influenza-like illness (ILI) and hospitalized severe acute respiratory tract infection (SARI) in Xinjiang from January 2024 to May 2024 for multi-pathogen detection. Then, the infection frequency of pathogens and their distribution characteristics in different months, genders, regions and case classifications were analyzed.

**Results** The positive infection rate of pathogens in 2791 patients was 48.30% (1348/2791). The proportion of patients infected with respiratory pathogens in the 0–9 age group was the highest. Of all pathogens detected, MP was most common in positive patients (22.03%). The highest frequency of multiple infections was SPn. RSV, FluA and FluB were the main infectious pathogens in January and February. The number of RV, HPIV and MP infections showed an increasing trend from January to May. Compared to female patients, male patients are more likely to be infected with ADV and SPn. Compared with hospitalized SARI patients, outpatient and emergency ILI patients were more susceptible to infection with ADV and FluB. However, hospitalized SARI patients were more susceptible to infection with RSV and MP. The positive infected patients mainly came from northern Xinjiang (60.83%). Compared with other regions, the proportion of ADV positive patients in northern Xinjiang was higher.

**Conclusion** This study revealed the distribution characteristics of pathogen infection in patients with respiratory tract infections in different months, genders, regions and case classifications during the seasonal changes of winter

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and spring in Xinjiang for the first time, which is helpful to formulate more effective treatment strategies and preventive measures.

**Clinical trial number** not applicable.

**Keywords** Respiratory tract infections, Multiplex PCR, Seasonal, Gender, Child, Viruses

## Background

Acute respiratory tract infections are very common and have high morbidity and mortality rates worldwide [1, 2]. Many pathogens can cause acute respiratory tract infections. In addition to bacteria, many pathogenic microorganisms are difficult to isolate and culture. These include some viruses that are usually considered to be the main cause of the disease, such as respiratory syncytial virus (RSV), adenovirus (ADV), human parainfluenza virus (HPIV), severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), influenza A virus (FluA), influenza B virus (FluB) [3, 4]. The effective treatment of respiratory tract infections relies on efficient diagnosis and rapid provision of appropriate treatment, usually in the form of antimicrobial therapy [5]. Influenza is an acute respiratory disease with high infectivity and global distribution [6, 7]. Children are the main group infected with influenza [8]. It presents in different clinical forms, from influenza-like illness (ILI) to severe acute respiratory tract infection (SARI) [9].

The Global Influenza Surveillance and Response System (GISRS, https://www.who.int/initiatives/global-influenza-surveillance-and-response-system), established by the World Health Organization (WHO), is a comprehensive network comprising National Influenza Centres (NICs), WHO Collaborating Centres (WHO CCs), and other key laboratories worldwide [10]. The system employs a multi-faceted approach to surveillance, including virological monitoring, epidemiological tracking, and clinical surveillance. Data collected by NICs are shared with WHO CCs for in-depth analysis, and the results are aggregated and disseminated through platforms like FluNet and FluID, which provide real-time global influenza activity updates. Influenza surveillance is carried out through influenza surveillance sentinel sites, and respiratory specimens are collected for multi-pathogen detection. Influenza surveillance is essential to monitor epidemic trends, guide the selection of strains for vaccine components, detect the emergence of pandemic potential viruses, and monitor their impact and spread [11, 12]. Surveillance data can also be used to promote prevention strategies, and provide information for policy development and public health interventions. Moreover, these surveillance data are also used to describe the burden of influenza. For low- and middle-income regions, the quantification of influenza burden is poor [8]. Therefore, for low- and middle-income regions, effective influenza surveillance can provide a better understanding of the impact of the disease to assess its severity and burden.

Xinjiang Uygur Autonomous Region is located in the northwest inland of China and is a typical underdeveloped region [13]. Its area is 1.6649 million square kilometers, accounting for about 1/6 of China's total land area. According to the 2023 national economic and social development statistics bulletin of Xinjiang, the permanent population is 25.98 million. Up to now, no relevant reports have been found for the surveillance of respiratory tract infections in Xinjiang. Therefore, to understand the characteristics and dynamic changes of multi-pathogen infection of respiratory tract infections during the seasonal changes in winter and spring in Xinjiang, this study collected 2791 outpatient and emergency ILI and hospitalized SARI samples in Xinjiang influenza surveillance sentinel hospitals from January 2024 to May 2024 for multiplex polymerase chain reaction (PCR) detection and statistical analysis.

## Methods

### Collection of samples

ILI was defined as fever (body temperature ≥ 38℃) with cough or sore throat. SARI diagnosis aligned with the definition outlined by the WHO [14, 15]. Hospitalization SARI refers to the occurrence of acute respiratory infection symptoms requiring overnight hospitalization, along with a history of fever (measured body temperature ≥ 38 ℃), accompanied by cough, shortness of breath or difficulty breathing, and the onset of the disease does not exceed 10 days. A total of 2791 patients were enrolled from January 2024 to May 2024. All sample types were throat swabs. Samples were collected from the Korla (Bazhou People's Hospital), Hami City (Hami Central Hospital), Kashgar Prefecture (The First People's Hospital), Karamay (Karamay Central Hospital), Urumqi (Urumqi First People's Hospital (Urumqi Children's Hospital) and Autonomous region People's Hospital) and Yining City (Yili Friendship Hospital) in Xinjiang. Among them, Karamay, Urumqi and Yining City belong to northern Xinjiang, Korla and Kashgar Prefecture belong to southern Xinjiang, and Hami City belong to eastern Xinjiang. The collected samples were tested for multi-pathogen, including RSV, ADV, rhinovirus (RV), HPIV, human metapneumovirus (HMPV), enterovirus (EV), human bocavirus (HBoV), severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), common human coronaviruses (OC43, 229E, HKU1 and NL63), FluA, FluB, mycoplasma pneumoniae (MP), chlamydia pneumoniae (CP) and streptococcus pneumoniae (SPn).

### Multi-pathogen detection

Nucleic acid was extracted from throat swab according to the corresponding requirements and procedures in the DNA/RNA extraction kit (Chongqing Zhongyuan Biotechnology Co., LTD. Nucleic acid extraction kit). The elution volume shall not be less than 50 μL. Then, multi-pathogen detection was performed using real-time PCR diagnostic kit rapid detection of multiple pathogens of national acute respiratory infectious diseases (B version, TaqMan Probe method, Beijing Applied Biotechnology Co., LTD). Cycle threshold (Ct) value > 38 or no detection was considered negative. The amplification curve was S-shaped, and the Ct value ≤ 38 was considered positive.

### Statistical analysis

Statistical analysis was performed using R Studio (version 4.3.1). $P < 0.05$ was considered statistically significant. The number and percentage of cases were used for statistical description of baseline characteristics. The pathogens frequency table was made based on the results of multiplex PCR pathogens detection, and the percentage of missing data was not calculated. Subgroup analysis was performed on gender and collection area, and chi-square test or Fisher exact probability method was used to compare the differences between groups.

**Table 1** Baseline characterization of positive and negative samples

| | **Total ($n = 2791$)** | **Negative ($n = 1443$)** | **Positive ($n = 1348$)** |
|---|---|---|---|
| Gender, *n* (%) | | | |
| Female | 1415 (50.70) | 766 (53.08) | 649 (48.15) |
| Male | 1376 (49.30) | 677 (46.92) | 699 (51.85) |
| Age, *n* (%) | | | |
| 0–9 | 846 (30.31) | 322 (22.31) | 524 (38.87) |
| 10–19 | 381 (13.65) | 185 (12.82) | 196 (14.54) |
| 20–29 | 307 (11.00) | 176 (12.20) | 131 (9.72) |
| 30–39 | 355 (13.06) | 187 (12.96) | 168 (12.46) |
| 40–49 | 195 (6.99) | 117 (8.11) | 78 (5.79) |
| 50–59 | 238 (8.53) | 146 (10.12) | 92 (6.82) |
| 60–69 | 202 (7.24) | 138 (9.56) | 64 (4.75) |
| 70–79 | 142 (5.09) | 89 (6.17) | 53 (3.93) |
| >80 | 125 (4.48) | 83 (5.75) | 42 (3.12) |
| Sample collection area, *n* (%) | | | |
| Northern Xinjiang | 1552 (55.61) | 732 (50.73) | 820 (60.83) |
| Southern Xinjiang | 806 (28.88) | 484 (33.54) | 322 (23.89) |
| Eastern Xinjiang | 433 (15.51) | 227 (15.73) | 206 (15.28) |
| Case classification, *n* (%) | | | |
| Outpatient and emergency ILI | 1813 (64.96) | 866 (60.01) | 947 (70.25) |
| Hospitalized SARI | 978 (35.04) | 577 (39.99) | 401 (29.75) |

ILI, Influenza-like illness; SARI, severe acute respiratory infection

## Results

### Baseline characteristics of study patients

A total of 2791 patients were enrolled in this study. The patients were divided into positive and negative groups according to whether the pathogens detection was positive. There were 1348 patients in the positive group and 1443 patients in the negative group (Table 1). The overall positive infection rate was 48.30%. Among the positive patients, the female infection rate was 48.15%, and the male infection rate was 51.85%. The proportion of patients infected with respiratory pathogens in the 0–9 age group was the highest. Moreover, with the increase of age, the infection rate showed an overall downward trend (Table 1). The positive infected patients mainly came from northern Xinjiang (60.83%). Moreover, 70.25% of the positive patients were outpatient and emergency ILI cases.

### Detection of multi-pathogen among the patients

The results of multiple PCR showed that there were 1193 (88.50%) patients of single pathogen infection and 155 (11.50%) patients of multiple infections among positive patients. The results of pathogen frequency detected by multiplex PCR is shown in Table 2. Among all detected pathogens, MP appeared the most frequently in positive patients (22.03%). It mainly shows as a single infection. This was followed by SARS-CoV-2 infection (18.18%), ADV infection (14.39%) and FluB infection (13.65%). The highest frequency of multiple infections was SPn, including 65 patients (48.87%) with double infections and 13 patients (59.09%) with triple and quadruple infections (Table 2). This result suggests that SPn was prone to multiple infections. In addition, multiple infections in positive patients of all age groups were also analyzed (Table 3). The result showed that the proportion of positive, double, triple and quadruple infections was the highest in children aged 0–9 years.

The monthly distribution of pathogens among positive patients is shown in Fig. 1. RSV and influenza virus (FluA and FluB) were the main infectious pathogens in January and February. The number of EV, HBoV and CP infections has been low from January to May. The number of RV, HPIV and MP infections showed an increasing trend from January to May. Moreover, MP was the main infectious pathogen in May. The number of SARS-CoV-2 infections increased significantly in March and April.

### Subgroup analysis based on gender, collection area and case classification of positive patients

The analysis of pathogen infections in gender subgroups showed significant differences in the distribution of ADV ($P < 0.001$), SARS-CoV-2 ($P = 0.023$) and SPn ($P = 0.001$) between females and males (Table 4). Compared to female patients, male patients were more likely to be

**Table 2** The frequency distribution of the pathogens among positive patients

| Pathogens | Frequency of occurrence in positive patients (*n* = 1348) | Single detection (*n* = 1193) | Double infection (*n* = 55) | Triple and quadruple infection (*n* = 22) |
|---|---|---|---|---|
| RSV | 82 (6.08) | 67 (5.62) | 12 (9.02) | 3 (13.64) |
| ADV | 194 (14.39) | 159 (13.33) | 27 (20.30) | 8 (36.36) |
| RV | 120 (8.90) | 81 (6.79) | 29 (21.80) | 10 (45.46) |
| HPIV | 58 (4.30) | 43 (3.60) | 10 (7.52) | 5 (22.73) |
| HMPV | 45 (3.34) | 33 (2.77) | 10 (7.52) | 2 (9.09) |
| EV | 7 (0.52) | 3 (0.25) | 2 (1.50) | 2 (9.09) |
| HBoV* | 2 (0.17) | 1 (0.08) | 1 (0.75) | 0 |
| SARS-CoV-2 | 245 (18.18) | 227 (19.03) | 10 (7.52) | 4 (18.18) |
| Common human coronaviruses | 58 (4.30) | 32 (2.68) | 19 (14.29) | 7 (31.82) |
| FluA | 101 (7.49) | 87 (7.29) | 13 (9.77) | 1 (4.55) |
| FluB | 184 (13.65) | 162 (13.58) | 19 (14.29) | 3 (13.64) |
| MP | 297 (22.03) | 243 (20.37) | 45 (33.83) | 9 (40.91) |
| CP* | 2 (0.17) | 2 (0.17) | 0 | 0 |
| SPn* | 131 (11.05) | 53 (4.44) | 65 (48.87) | 13 (59.09) |

"*" indicates that HBoV, CP, and SPn were not tested in 162 patients, and data that were not tested will not be counted. As for the missing detection results of HBoV, CP, and SPn in some patients, this was primarily due to the initial phase of the project, where the procurement of detection reagents required a certain lead time. The procurement progress in some laboratories was delayed, resulting in incomplete coverage of pathogen detection during the initial stages

**Table 3** Distribution of multiple infections in positive patients of all ages

| Age | Positive patients (*n* = 1348) | Double infection (*n* = 133) | Triple and quadruple infection (*n* = 22) |
|---|---|---|---|
| 0–9 | 524 (38.87) | 88 (66.17) | 14 (63.63) |
| 10–19 | 196 (14.54) | 18 (13.53) | 6 (27.27) |
| 20–29 | 131 (9.72) | 2 (1.50) | 0 |
| 30–39 | 168 (12.46) | 6 (4.51) | 1 (4.55) |
| 40–49 | 78 (5.79) | 6 (4.51) | 0 |
| 50–59 | 92 (6.82) | 4 (3.01) | 0 |
| 60–69 | 64 (4.75) | 4 (3.01) | 1 (4.55) |
| 70–79 | 53 (3.93) | 3 (2.26) | 0 |
| > 80 | 42 (3.12) | 2 (1.50) | 0 |

infected with ADV and SPn. Compared to male patients, female patients were more likely to be infected with SARS-CoV-2.

The analysis of pathogen infections in collection area subgroups showed significant differences in the distribution of RSV ($P < 0.001$), ADV ($P < 0.001$), RV ($P = 0.011$), SARS-CoV-2 ($P = 0.003$), FluA ($P = 0.033$), FluB ($P = 0.005$), CP ($P = 0.030$) and SPn ($P = 0.003$) among northern Xinjiang, southern Xinjiang and eastern Xinjiang (Table 5). Compared with other regions, the proportion of RSV, RV, FluA and SPn positive patients in southern Xinjiang were higher. However, the proportion of SARS-CoV-2, FluB and CP positive patients in eastern Xinjiang were higher. The proportion of ADV positive patients in northern Xinjiang was higher.

The analysis of pathogen infections in case classification subgroups showed significant differences in the distribution of RSV ($P = 0.017$), ADV ($P < 0.001$), FluB ($P < 0.001$) and MP ($P = 0.005$) between outpatient and emergency ILI and hospitalized SARI (Table 6). Compared with hospitalized SARI patients, outpatient and emergency ILI patients were more susceptible to infection with ADV and FluB. Compared with outpatient and emergency ILI patients, hospitalized SARI patients were more susceptible to infection with RSV and MP.

## Discussion

Monitoring the annual, seasonal and age-based distribution of respiratory tract infection effects will help determine geographical differences, detect epidemics, and also support slowing down the spread of antimicrobial resistance by preventing unnecessary antimicrobial use [16, 17]. In this study, multiplex PCR was performed on the collected 2791 outpatient and emergency ILI and hospitalized SARI samples to detect the multi-pathogen infections characteristics of respiratory tract infections during the seasonal changes in winter and spring in Xinjiang. Multiplex PCR detection showed that 1348 patients had pathogen infections. The infection rate was 48.30%. Of the 1348 positive patients, 947 (70.25%) were outpatient and emergency ILI and 401 (29.75%) were hospitalized SARI. The proportion of patients infected with respiratory pathogens in the 0–9 age group was the highest, which implies that children are the main infected population. In addition, the positive infected patients mainly came from northern Xinjiang (60.83%).

MP was the pathogen with the highest frequency (22.03%) in positive patients. MP is a highly infectious bacterium and an important cause of respiratory tract

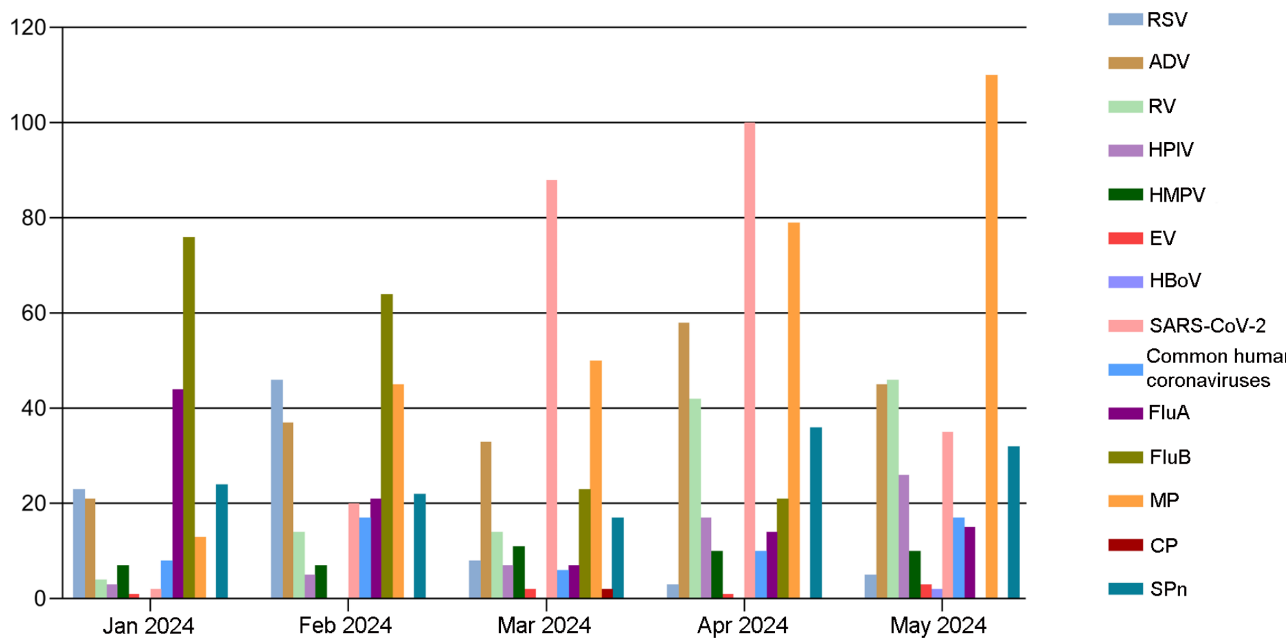


**Fig. 1** Monthly distribution of the detected pathogens among positive patients

**Table 4** Analysis of pathogen infection in gender subgroups of positive patients

| Pathogens | Total (*n* = 1348) | Female (*n* = 649) | Male (*n* = 699) | *P* |
|---|---|---|---|---|
| RSV | 82 (6.08) | 42 (6.47) | 40 (5.72) | 0.565 |
| ADV | 194 (14.39) | 67 (10.32) | 127 (18.17) | < 0.001 |
| RV | 120 (8.90) | 55 (8.47) | 65 (9.30) | 0.595 |
| HPIV | 58 (4.30) | 26 (4.01) | 32 (4.58) | 0.605 |
| HMPV | 45 (3.34) | 21 (3.24) | 24 (3.43) | 0.840 |
| EV | 7 (0.52) | 4 (0.62) | 3 (0.43) | 0.717 |
| HBoV* | 2 (0.17) | 1 (0.17) | 1 (0.17) | > 0.999 |
| SARS-CoV-2 | 245 (18.18) | 134 (20.65) | 111 (15.88) | 0.023 |
| Common human coronaviruses | 58 (4.30) | 23 (3.54) | 35 (5.01) | 0.186 |
| FluA | 101 (7.49) | 50 (7.70) | 51 (7.30) | 0.776 |
| FluB | 184 (13.65) | 97 (14.95) | 87 (12.45) | 0.182 |
| MP | 297 (22.03) | 146 (22.50) | 151 (21.60) | 0.692 |
| CP* | 2 (0.17) | 2 (0.34) | 0 (0.00) | 0.240 |
| SPn* | 131 (11.05) | 47 (8.09) | 84 (13.88) | 0.001 |

"*" indicates that HBoV, CP, and SPn were not tested in 68 female patients and 94 male patients, and data that were not tested will not be counted

infections in children and adults [18]. MP occurs endemically worldwide in many different climates. There may be a positive correlation between warmer temperatures and MP infections, which may help explain the increase numbers that may occur during warmer months [19, 20]. Herein, the number of MP infections showed an increasing trend from January to May, which again hinted at this correlation. Previous studies have shown that MP is the most common pathogen in SARI [21, 22]. In this study, the analysis of pathogen infections in case classification subgroups showed hospitalized SARI patients were more susceptible to infection with MP. Therefore, it is important to pay attention to MP infection for hospitalized SARI patients in Xinjiang.

Influenza virus and human RSV are major threats to global public health [23]. RSV infection is most likely to affect the respiratory system. Most of the damage to the airways is mediated by the immune response, not by viral replication itself [24]. Generally, about 3 to 7 days after infection, patients begin to have some common symptoms, including fever, runny nose and cough [25]. Generally, the infection rate of RSV is high in winter and begins to decline in early spring [26]. A study also showed that the RSV positive rate of SARI was higher than that of ILI [27], which was consistent with the results of this study. Both FluA and FluB can cause respiratory tract infections in humans and even cause significant morbidity and mortality [28]. The main viruses commonly diagnosed in

**Table 5** Analysis of pathogen infection in collection area subgroups of positive patients

| Pathogens | Total (n = 1348) | Northern Xinjiang (n = 820) | Southern Xinjiang (n = 332) | Eastern Xinjiang (n = 206) | P |
|---|---|---|---|---|---|
| RSV | 82 (6.08) | 38 (4.63) | 35 (10.87) | 9 (4.37) | < 0.001 |
| ADV | 194 (14.39) | 155 (18.90) | 25 (7.76) | 14 (6.80) | < 0.001 |
| RV | 120 (8.90) | 63 (7.68) | 42 (13.04) | 15 (7.28) | 0.011 |
| HPIV | 58 (4.30) | 32 (3.90) | 17 (5.28) | 9 (4.37) | 0.586 |
| HMPV | 45 (3.34) | 33 (4.02) | 5 (1.55) | 7 (3.40) | 0.112 |
| EV | 7 (0.52) | 5 (0.61) | 2 (0.62) | 0 (0.00) | 0.746 |
| HBoV* | 2 (0.17) | 0 (0.00) | 2 (0.62) | 0 (0.00) | 0.104 |
| SARS-CoV-2 | 245 (18.18) | 137 (16.71) | 53 (16.46) | 55 (26.70) | 0.003 |
| Common human coronaviruses | 58 (4.30) | 36 (4.39) | 13 (4.04) | 9 (4.37) | 0.964 |
| FluA | 101 (7.49) | 50 (6.10) | 34 (10.56) | 17 (8.25) | 0.033 |
| FluB | 184 (13.65) | 119 (14.51) | 28 (8.70) | 37 (17.96) | 0.005 |
| MP | 297 (22.03) | 191 (23.29) | 66 (20.50) | 40 (19.42) | 0.364 |
| CP* | 2 (0.17) | 0 (0.00) | 0 (0.00) | 2 (0.97) | 0.030 |
| SPn* | 131 (11.05) | 72 (10.94) | 48 (14.91) | 11 (5.34) | 0.003 |

"*" indicates that there are 162 patients in northern Xinjiang who have not tested HBoV, CP, and SPn, and the untested data are not counted

**Table 6** Analysis of pathogen infection in case classification subgroups of positive patients

| Pathogens | Total (n = 1348) | Outpatient and emergency ILI (n = 947) | Hospitalized SARI (n = 401) | P |
|---|---|---|---|---|
| RSV | 82(6.08) | 48(5.07) | 34(8.48) | 0.017 |
| ADV | 194(14.39) | 156(16.47) | 38(9.48) | < 0.001 |
| RV | 120(8.90) | 83(8.76) | 37(9.23) | 0.785 |
| HPIV | 58(4.30) | 39(4.12) | 19(4.74) | 0.608 |
| HMPV | 45(3.34) | 33(3.48) | 12(2.99) | 0.646 |
| EV | 7(0.52) | 3(0.32) | 4(1.00) | 0.206 |
| HBoV* | 2(0.17) | 1(0.11) | 1(0.25) | 0.301 |
| SARS-CoV2 | 245(18.18) | 163(17.21) | 82(20.45) | 0.159 |
| Common human coronaviruses | 58(4.30) | 47(4.96) | 11(2.74) | 0.066 |
| FluA | 101(7.49) | 75(7.92) | 26(6.48) | 0.360 |
| FluB | 184(13.65) | 150(15.84) | 34(8.48) | < 0.001 |
| MP | 297(22.03) | 189(19.96) | 108(26.93) | 0.005 |
| CP* | 2(0.17) | 1(0.11) | 1(0.25) | 0.301 |
| SPn* | 131(11.05) | 94(9.93) | 37(9.23) | 0.455 |

ILI, Influenza-like illness; SARI, severe acute respiratory infection. "*" indicates that HBoV, CP, and SPn were not tested in 120 outpatient and emergency ILI patients and 42 hospitalized SARI patients, and data that were not tested will not be counted

association with ILI are FluA, FluB and RSV. Moreover, FluA and FluB infections peak in winter [29]. Compared with FluA and FluB, RSV infection or its complications are associated with higher mortality [29]. Herein, RSV and influenza virus (FluA and FluB) were the main infectious pathogens in January and February. Therefore, influenza virus and RSV infections should be the focus of attention during the cold winter months in Xinjiang, and effective preventive and therapeutic measures should be provided.

ADV is a highly infectious pathogen that can cause a variety of diseases, including respiratory diseases [30]. The ADV is divided into 7 species A-G according to the classification criteria of the Human Adenovirus Working Group (http://hadvwg.gmu.edu/). Species B, C and E are commonly associated with respiratory tract infections [30]. ADV is also an important pathogen for respiratory tract infections in children [31]. Some previous studies have shown that ADV infection does not have gender preference [32, 33], but other study has shown that ADV is more likely to infect men. The reason for this opposite result may have something to do with geographical distribution. In this study, gender subgroup analysis showed that ADV was more susceptible to infection in male patients, and the specific reasons for this need to be further studied. In addition, gender subgroup analysis showed that SPn was also more susceptible to infection in male patients. SPn is a Gram-positive bacterial pathogen that can colonize the mucosal surfaces of the nasopharynx and upper respiratory tract of the host [34]. The analysis of patients recruited from 9 European countries showed that the male carrier rate was higher than that of women [35], which was consistent with the results of this study. Carrying is usually asymptomatic, however, SPn can become invasive, spreading from the upper respiratory tract to the lungs, causing pneumonia and spreading to other organs to causing serious illness [36]. Therefore, compared with female patients in Xinjiang, male patients with respiratory infection should pay more attention to the infection of ADV and SPn.

SARS-CoV-2 emerged in December 2019 and has caused a pandemic of acute respiratory diseases. The severity of the disease ranges from asymptomatic infection to severe disease and death [37, 38]. Higher population aggregation is a direct factor affecting SARS-CoV-2, and weather is an indirect factor. Low temperature and significant diurnal temperature difference lead to decreased human immunity and promote SARS-CoV-2 infection [39]. In addition, previous reports have shown that there are significant gender differences in clinical outcomes of SARS-CoV-2 infection [40, 41]. This difference can be influenced by gender behavior, occupation, and habits [42]. For example, the use of nicotine, large public gatherings or close contact with outdoor people, the wearing of masks, personal hygiene and health care. SARS-CoV-2 causes a long course of disease beyond acute illness, and the prevalence of this "post-COVID-19 syndrome" and the number of persistent symptoms is higher in women than in men [40]. Female gender was a risk factor for reinfection with SARS-CoV-2 [43]. In this study, gender subgroup analysis showed that SARS-CoV-2 was more susceptible to infection in female patients, and the specific reasons for this need to be further studied. The gender preference of pathogen infection suggests that the focus and preventive measures for male and female patients should be targeted.

In addition to MP, this study also showed that RV and HPIV showed an increasing trend from January to May. RV is the leading cause of acute respiratory tract infections [44]. In temperate climates, RV is present throughout the year, with peak infections observed in spring and autumn [45]. HPIV is a single-stranded coated RNA virus of the paraviruses family that can cause respiratory disease in children and adults [46]. A retrospective study in China showed that the positive infection rate of HPIV in patients with acute lower respiratory tract infections was higher in spring and summer months [47]. Moreover, the monthly distribution of pathogens also showed that the number of SARS-CoV-2 infections increased significantly in March and April. MP was the main infectious pathogen in May. RSV, FluA and FluB were the main infectious pathogens in January and February. The above results suggest that during the winter and spring seasonal changes in Xinjiang, the types of pathogen infections fluctuate with temperature and season. This discovery is beneficial for the prevention and management of respiratory tract infections in Xinjiang.

Notably, the analysis of pathogen infections in collection area subgroups showed differences in the proportion of infections among northern Xinjiang, southern Xinjiang and eastern Xinjiang. Compared with other regions, the proportion of RSV, RV, FluA and SPn positive patients in southern Xinjiang was higher. However, the proportion of SARS-CoV-2, FluB and CP positive patients in eastern Xinjiang was higher. CP is an obligate intracellular pathogen that can cause a variety of acute and chronic human diseases, including pneumonia and other respiratory diseases [48]. The proportion of ADV positive patients in northern Xinjiang was higher. The results contribute to understanding the regional characteristics of pathogen infection in Xinjiang to help develop targeted treatment and prevention measures. However, the reasons for this regional difference are unclear and worthy of further study.

There are some limitations in this study. Firstly, the sample size was not sufficient, with only 2791 samples. Therefore, more samples need to be collected for analysis and statistical verification in the later stage to obtain more accurate and reliable results. Secondly, the duration of sample collection is not long enough and the collection year is single. Large-scale sample collections of longer duration and multiple years allow better assessment of the epidemiological characteristics of pathogen infections.

## Conclusion

This study highlights the complex multi-pathogen landscape of respiratory tract infections during the winter-spring transition in Xinjiang. The high detection rate (48.30%) of respiratory pathogens underscores the significant burden of respiratory tract infections in this region. The findings reveal distinct epidemiological patterns, with RSV and FluA/FluB dominating in winter months, while RV, HPIV, and MP infections increased as spring progressed. Children aged 0–9 years were the most vulnerable group. Regional disparities were evident, with northern Xinjiang reporting the highest proportion of positive cases. Additionally, gender and case classification differences were observed. Compared to female patients, male patients are more likely to be infected with ADV and SPn. Compared with hospitalized SARI patients, outpatient and emergency ILI patients were more susceptible to infection with ADV and FluB. However, hospitalized SARI patients were more susceptible to infection with RSV and MP. These insights emphasize the need for targeted surveillance and preventive strategies tailored to seasonal, demographic, and regional variations to effectively manage respiratory infections in Xinjiang. In this study, the multi-pathogen infection characteristics of respiratory tract infectious diseases during seasonal changes in winter and spring in Xinjiang were revealed for the first time. Moreover, the distribution characteristics of the pathogens in different months, genders, regions and case classifications were revealed, which can facilitate the development of more effective treatment strategies and preventive measures.

**Abbreviations**

| | |
|---|---|
| ILI | Influenza-like illness |
| SARI | Severe acute respiratory infection |
| RSV | Respiratory syncytial virus |
| ADV | Adenovirus |
| HPIV | Human parainfluenza virus |
| FluA | influenza A virus |
| FluB | influenza B virus |
| PCR | Polymerase chain reaction |
| RV | Rhinovirus |
| HMPV | Human metapneumovirus |
| EV | Enterovirus |
| HBoV | Human bocavirus |
| SARS-CoV-2 | Severe acute respiratory syndrome coronavirus 2 |
| MP | Mycoplasma pneumonia |
| CP | Chlamydia pneumonia |
| SPn | Streptococcus pneumonia |
| Ct | Cycle threshold |

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**Author contributions**
Conception and design: JH, XMAdministrative support: HWProvision of study materials or samples: XZ, YC, NA, QLCollection and assembly of data: HAData analysis and interpretation: JH, XMAll authors have made important contributions to data analysis, drafting the article or revising the article.

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**Data availability**
All data generated or analyzed during this study are included in this published article. The data generated during and/or analysed during the current study are available from the corresponding author (Haiyan Wu: 147597960@qq.com) on reasonable request.

## Declarations

**Ethics approval and consent to participate**
The present study was approved by the Ethics Committee of Xinjiang Center for Disease Control and Prevention. This study complied with the Declaration of Helsinki. The informed consent was obtained from the all participants.

**Consent for publication**
Not Applicable.

**Competing interests**
The authors declare no competing interests.

**Conflict of interest**
The authors declare that they have no conflict of interest.

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