Epidemiological Study of Respiratory Virus Infections among Hospitalized Children Aged 14 Years and Younger during COVID-19 Pandemic in Wuhan, China, 2018–2022

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Abstract

Introduction: The viral etiological characteristics and prevalence of hospitalized children with acute respiratory tract infection were preliminary studied in Wuhan City during the COVID-19 pandemic, to provide a reliable scientific basis for better understanding of the role of various pathogens in cases and for the prevention and clinical treatment of acute respiratory tract infection. **Methods:** A total of 69,086 children with acute respiratory infections hospitalized and treated in our department from January 2018 to December 2022 were enrolled as our research subjects. Sociodemographic and clinical data as well as nasopharyngeal samples were collected from patients. Respiratory syncytial virus (RSV), adenovirus (ADV), infuenza virus A (FluA), infuenza virus B (FluB), and parainfluenza virus (PIV) were detected by direct immunofluorescence (DFA) to understand and analyze the epidemic characteristics of respiratory pathogens in children during the COVID-19 pandemic. **Results:** The total detection rate of respiratory pathogens was 24.52% of the 69,086 hospitalized children. The frequency of respiratory viruses in those ADV, RSV, FluA, FluB, and PIV was 14.67%, 46.40%, 7.76%, 5.23%, and 25.95%. There were significant differences between the various pathogens ($P < 0.001$). There were the fewest pathogen-positive patients and positive detection rate in 2020 during the COVID-19 pandemic. There were significant differences in the pathogen detection rate among different years ($P < 0.001$). In addition, the results showed that the total detection rate of respiratory virus tested in different age groups was significantly different ($P < 0.001$). The positive detection rate was highest in the 1–3-year-old age group, which is prone to acute respiratory infections. We also found that different pathogens showed obvious seasonal fluctuation and epidemic. RSV reached its peak in winter. ADV is mainly prevalent in spring and summer. FluA has a high detection rate in winter. Winter and spring are the peak seasons for FluB infection, whereas PIV is detected in all seasons, with a higher incidence rate in the spring and summer. **Conclusion:** The epidemiological distribution of pathogens of acute respiratory tract infection in hospitalized children in Wuhan from 2018 to 2022 varies with gender, age, and season. Nonpharmaceutical interventions (NPIs) were implemented as control measures worldwide and reduced the transmission of respiratory pathogens. NPIs are likely to be the primary driver of the dramatic reduction in respiratory virus infection activity in the early stages of the COVID-19 pandemic, to dissolving NPIs can lead to a recurrence of viral infection pathogens, especially in children.

Keywords: Acute respiratory tract infection, children, epidemiology, hospitalization, nonpharmaceutical interventions, respiratory viruses

Introduction

Acute respiratory infection (ARI) is one of the most common infectious diseases in childhood worldwide.[1] ARI represent a major burden on the health-care systems. Globally, ARIs are the most common cause of illness in all ages. More than 40% of preschoolers and 30% of school-age children develop influenza during the influenza epidemic season. In addition, younger children are more susceptible than older children and adults.[2] Other studies[3] have reported that acute respiratory infections are a leading cause of death in young children <5 years of age globally. Although bacteria, fungi, and mycoplasmas can lead to ARI, viruses are the most common causative pathogens. ARI is caused by a variety of different pathogens, and the current

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treatment options mainly include antiviral drugs, antitussive drugs, and nonsteroidal anti-inflammatory drugs. There is no effective and specific treatment strategy, which in turn means that most antibiotic treatments are empiric.[4]

As COVID-19 progressed and recurred, a range of nonpharmaceutical interventions (NPIs),[5,6] including mask wearing, hand hygiene disinfection, social distancing, travel restrictions, home quarantine, and school closures, prevented the transmission of most respiratory viruses and were associated with an unexpected suppression of the activity of several seasonal respiratory pathogens.[7] Due to the expected resumption of seasonal respiratory virus transmission in December 2022, when health restrictions are lifted in Wuhan, it is important to fully understand the vulnerable populations, disease severity, transmission, and mode of transmission of multiple respiratory pathogens to control the spread of respiratory viruses.[8] The objective of this study was to analyze the epidemiological characteristics of respiratory viruses such as adenovirus (ADV), respiratory syncytial virus (RSV), influenza virus A, (FLuA), influenza virus B (FLuB), and parainfluenza virus (PIV) in ARI among hospitalized children during the COVID-19 pandemic in Wuhan, to provide a scientific basis for formulating prevention strategy, early antiviral therapy, and appropriate infection control measures.

Methods

Participants

A total of 69,086 hospitalized children under 14 years old and showed signs of ARI who were treated at Maternal and Child Health Hospital of Hubei Province from January 2018 to December 2022 were included in the study. Some digital clinical data, including demographic, epidemiological, diagnostic, and laboratory data, were recorded through the hospital electronic medical record system. Meanwhile, the research objects with incomplete medical records were excluded to ensure the representativeness and homogeneity of the research samples.

ARI cases are defined as patients who have had a fever ≥38°C within the past week or with one of the following respiratory symptoms: cough, sore throat, sputum, chills, shortness of breath, and abnormal auscultic breath sounds. Patients with fever caused by acute cholecystitis, central nervous system, urinary tract, gastrointestinal, and other infections were excluded from the study. Inclusion criteria were (1) confirmed ARI and (2) the age ranged from 28 days to 14 years. The study was conducted under the supervision of the Ethics Committee of Maternal and Child Health Hospital of Hubei Province.

Laboratory analysis

Throat swab sample collection

Throat respiratory specimens were collected by senior clinical staff who will rotate the nasopharyngeal swab 2–3 times in the nasopharynx of the children, to obtain mucosal epithelial cells and promptly put the swab into a special tube containing 1 ml sterile saline for immediate examination within 24 h after hospitalization. Five common respiratory viruses were detected by direct immunofuorescence (DFA), including ADV, RSV, FLuA, FLuB, and PIV viruses. The test kit was purchased from Hyde Diagnostics Inc. (USA). The specific operation process is closely in accordance with manufacturer's instructions. The results were interpreted by the positive criteria under a fluorescence microscope.

Statistical analysis

Statistical analysis was performed using the SPSS software version 22.0 (SPSS, Inc., Chicago, IL, USA). Measurement data with nonnormal distribution were described by Median (range), and *t*-test was used for the comparison between the groups. Infection rates were analyzed using the Chi-square test for ratio comparison. $P < 0.05$ was considered statistically significant.

Results

Clinical data on hospitalized children with acute respiratory tract infection before and after COVID-19 pandemic

During the study period from January 2018 to December 2022, 69,086 patients were analyzed with ARI caused by five respiratory viruses. The characteristics of the children included in this study are summarized in Table 1. Among these, 40,880 (59.17%) were male and 28,206 (40.83%) were female. Meanwhile, for the gender analysis in Table 2, the result showed that the positive rates of respiratory virus infections in males were higher than that of females between 2018 and 2022, suggesting that boys are more susceptible to respiratory virus infections than girls before and after the COVID-19 pandemic. There were significant differences detected by gender between the groups ($P = 0.0003$). The age of patients ranged from 1 day to 14 years. The frequency of virus positive detection in those aged ≤31 days, 31 days–1 year, 1–3 years, 4–6 years, 7–12 years, and >12 years were 4.34%, 26.45%, 46.42%, 17.09%, 5.56%, and 0.14%, respectively, with the positivity in 1–3 years old being significantly greater compared to the other age groups ($P < 0.0001$). Most patients (77.21%) with acute respiratory tract infection were under 6 years old.

Table 1: Sociodemographic characteristics of participants (*n*=69,086) in the study

Variables	Category	Total (*n*=69,086), *n* (%)
Sex	Male	40,880 (59.17)
	Female	28,206 (40.83)
Age of child	≤31 days	3002 (4.34)
	>31 days–<1 year	18,273 (26.45)
	1–3 years	32,068 (46.42)
	4–6 years	11,808 (17.09)
	7–12 years	3839 (5.56)
	>12 years	96 (0.14)
Ethnicity	Han Chinese	69,086 (100)

Distribution of pathogen-positive patients between 2018 and 2022

In this study, respiratory pathogens were detected in 16,943 of the 69,086 hospitalized children, and the detection rate was 24.52%. The frequency of respiratory viruses in those ADV, RSV, FluA, FluB, and PIV was 14.67% (2485/16,943), 46.40% (7861/16,943), 7.76% (1315/16,943), 5.23% (886/16,943), and 25.95% (4396/16,943) [Figure 1], and the detection rate of RSV was the highest. Furthermore, there were significant differences between the various pathogens ($\chi^2 = 11950.56$, $P < 0.001$).

Based on our retrospective data collected from the hospitalized patients diagnosed with ARI, the number of laboratory-confirmed ARI cases decreased from 18,140 in 2018 to 7907 in 2020, then increased from 12,202 to 13,137 in the first and second years after the COVID-19 epidemic [Figure 2a]. The data results indicated that there were the fewest pathogen-positive patients and positive detection rate in 2020 between 2018 and 2022. The number of positive detections of various respiratory viruses in 2019 was the largest [Figure 2b]. It is the same as the positive detection rate [Figure 2c]. There were significant differences in the pathogen detection rate among different years ($\chi^2 = 235.48$, $P < 0.001$).

Distribution of pathogen-positive patients in different age groups

Table 3 shows that the total detection rate of respiratory virus tested in different age groups was significantly different ($P < 0.001$). The total detection rate of respiratory virus in >31 days, <1 year, and 1–3-year-old groups was higher than that in other groups, and there were statistically significant differences with other groups ($P < 0.05$). The detection rates of the five respiratory viruses were broadly consistent with their overall detection levels among different age groups, with a decreasing trend in the detection rates of children of all ages after 7 years old. In addition, RSV was the predominant respiratory virus among children <3 years old. RSV accounted for 44.42% of viruses that cause acute respiratory illnesses, and second was PIV viruses, which showed the highest detection rate in the >31 days and <1-year age group. The detection rates of ADV, RSV, FluA, FluB, and PIV among the five respiratory viruses were statistically significant in different age groups ($P < 0.001$).

In addition, the results showed that there were differences in the detection rates of pathogens in different age groups during 2018–2022 [Figure 3]. The positive rate of viruses in the age group of 1–3 years was the highest, and ARI were more likely to occur. During the COVID-19 outbreak, the positive number of each pathogen decreased significantly, and the detection rate of five different viruses also changed. In ≤31-day group, the detection rate of FluB increased, while the RSV decreased. The detection rates of five viruses decreased in >31 days, <1 year, 1–3 years, and 7–12 years groups. Moreover, PIV increased slightly in the 4–6-year group, whereas other viruses decreased; in >12-year group, the FluB detection rate increased. Broadly speaking, the detection rate of most pathogens decreased significantly in all

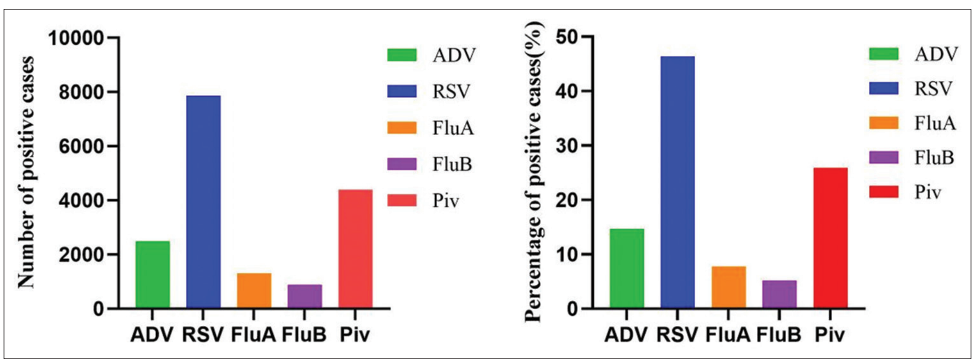

Figure 1: The number and percentage of positive detections of each various respiratory viruses. ADV: Adenovirus, RSV: Respiratory syncytial virus, PIV: Parainfluenza virus, FluA: Infuenza virus A, FluB: Infuenza virus B

Table 2: Sociodemographic characteristics of participants (*n*=69,086) in the study between 2018 and 2022

Variables	Category	2018 (*n*=18,140), *n* (%)	2019 (*n*=17,700), *n* (%)	2020 (*n*=7907), *n* (%)	2021 (*n*=12,202), *n* (%)	2022 (*n*=13,137), *n* (%)	χ^2	*P*
Sex	Male	10,906 (60.12)	10,436 (58.96)	4730 (59.82)	7237 (59.31)	7571 (57.63)	21.477	0.0003
	Female	7234 (39.88)	7264 (41.04)	3177 (41.18)	4965 (40.69)	5566 (42.37)		
Age of child (years)	≤31 days	1020 (5.62)	992 (5.60)	522 (6.60)	171 (1.40)	297 (2.26)	2177.20	<0.0001
	>31 days–<1 year	5754 (31.72)	4819 (27.23)	2264 (28.63)	2693 (22.07)	2743 (20.88)		
	1–3 years	8234 (45.39)	8104 (45.79)	3542 (44.80)	6426 (52.66)	5762 (43.86)		
	4–6 years	2424 (13.36)	2787 (15.75)	1152 (14.57)	2271 (18.61)	3174 (24.16)		
	7–12 years	684 (3.77)	972 (5.49)	407 (5.15)	615 (5.04)	1161 (8.84)		
	>12 years	24 (0.14)	26 (0.15)	20 (0.25)	26 (0.21)	0		

Table 3: Detection rates of five common respiratory viruses in children with acute respiratory infection in different age groups

Age category	Total detection rate (*n*/*n*)	ADV (%)	RSV (%)	FluA (%)	FluB (%)	PIV (%)
≤31 days	13.32 (400/3002)	3 (0.10)	312 (10.39)	11 (0.37)	1 (0.03)	73 (2.43)
>31 days–<1 year	29.56 (5401/18,273)	252 (1.38)	3057 (16.73)	315 (1.72)	128 (0.70)	1659 (9.08)
1–3 years	26.35 (8451/32,068)	1277 (3.98)	3987 (12.43)	640 (2.00)	332 (1.04)	2220 (6.92)
4–6 years	18.56 (2192/11,808)	801 (6.78)	460 (3.90)	287 (2.43)	242 (2.05)	389 (3.29)
7–12 years	12.89 (495/3839)	151 (3.93)	45 (1.17)	61 (1.59)	182 (4.74)	54 (1.41)
>12 years	4.17 (4/96)	1 (1.04)	0	1 (1.04)	1 (1.04)	1 (1.04)
χ^2	1040.14	727.65	1621.70	62.50	518.95	670.42
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

ADV: Adenovirus, RSV: Respiratory syncytial virus, FluA: Infuenza virus A, FluB: Infuenza virus B, PIV: Parainfluenza virus

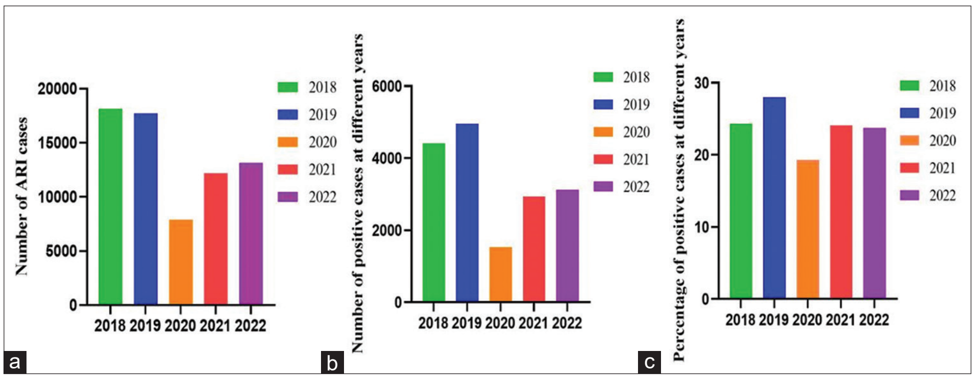

Figure 2: The number and percentage of positive pathogens at different years. (a) The number of ARI cases between 2018 and 2022, (b) The number of positive cases between 2018 and 2022, (c) The percentage of positive cases between 2018 and 2022. ARI: Acute respiratory infection

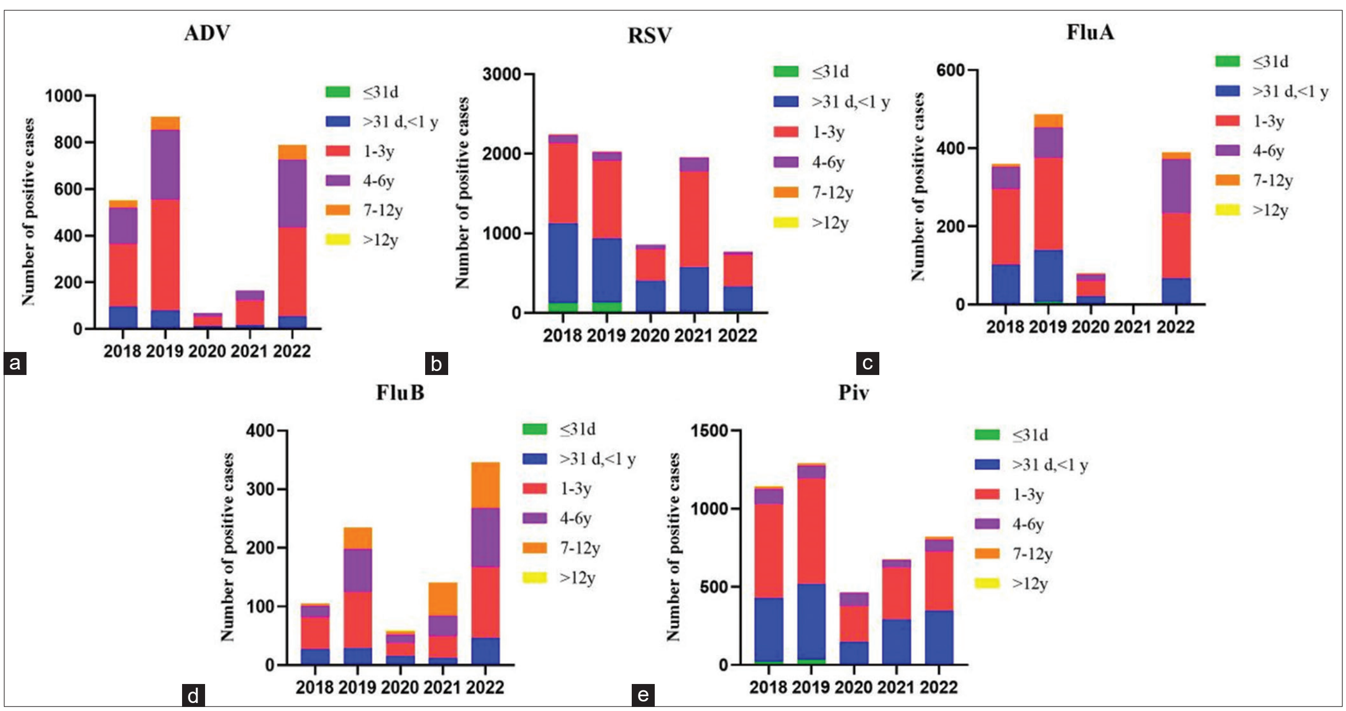

Figure 3: Distribution of respiratory pathogens in the different age groups between 2018 and 2022. (a) Adenovirus, (b) Respiratory syncytial virus, (c) FluA, (d) FluB, (e) Parainfluenza virus. ADV: Adenovirus, RSV: Respiratory syncytial virus, PIV: Parainfluenza virus, FluA: Infuenza virus A, FluB: Infuenza virus B

age groups during the COVID-19 pandemic, especially in 2020. After the epidemic became normal, the detection rate of each pathogen gradually increased. By 2022, the detection rate raised to the level of the same period as in 2019 [Figure 3].

Distribution of respiratory pathogens in different months between 2018 and 2022

From Figure 4, we observed that ADV is mainly prevalent in the spring and summer [Figure 4a], whereas RSV has a higher detection rate in spring, autumn, and winter, which shows a clear seasonal distribution and reaches the peak of infection in winter [Figure 4b]; FluA detection has significant seasonal fluctuation and prevalence, with relatively high levels in winter and relatively low levels in spring [Figure 4c]; FluB has a higher detection rate in winter and spring [Figure 4d]; and PIV has been detected in all seasons, with a higher incidence in spring and summer [Figure 4e]. The above phenomenon was particularly evident in 2019 and 2022, but no such phenomenon was observed in 2020 and 2021. From Table 4, it can be seen that the distribution of various pathogens during the COVID-19 epidemic was almost uniform throughout the year, and the positive rate decreased significantly. The detection rate reached its lowest level in 2020, with a significant difference compared to other years ($P < 0.001$).

Discussion

Acute respiratory infection (ARI) is a group of common diseases with respiratory symptoms such as fever, cough, and shortness of breath, which has a high morbidity and mortality and is one of the main causes of death in children under 5 years of age.[9,10] ARIs pose a serious threat to children's health and have become a persistent and widespread public health problem worldwide, bringing a heavy economic burden to the society and families, especially in developing countries.[11,12]

The pathogens of ARI infection in children include viruses, bacteria, atypical pathogens, and fungus, with viral infections being the most common, such as ADV, RSV, FluA, FluB, and PIV.[13-15] The prevalence of different viruses is correlated with the age, season, and region of onset. However, China has implemented effective containment measures during the COVID-19 epidemic, and the implementation of some contact restriction measures may lead to a decrease in ARI caused by respiratory pathogens. At the same time, due to social distancing measures, wearing masks, and paying attention to respiratory etiquette, and other prevention and control measures, the rate of acute respiratory infections caused by various viruses will also be significantly reduced.[16,17] To fully understand the prevalence of common respiratory pathogens in children during the COVID-19 epidemic and provide pathogenic basis for the prevention and control of acute respiratory infections in children, our research selected children aged 0–14 years who were hospitalized in Maternal and Child Health Hospital of Hubei Province due to ARI from January 2018 to December 2022 as research objects. Nasopharyngeal swab samples from 69,086 children were collected for surveillance and epidemiological analysis of respiratory viruses.[18]

The results of this study showed that there were significant differences in pathogen infection rates among children of different genders, with males significantly higher than females. The literature[19] reported that the detection rate of males was higher than that of females, which was consistent with our results. Nevertheless, Ham *et al*.[20] found that the overall incidence between male and female patients showed no statistically significant difference; however, there were statistically significant differences between male and female patients in whole flu antigen, and boys are more susceptible to respiratory infections, inconsistent with our study. Different analyses of positivity rates may be related to different

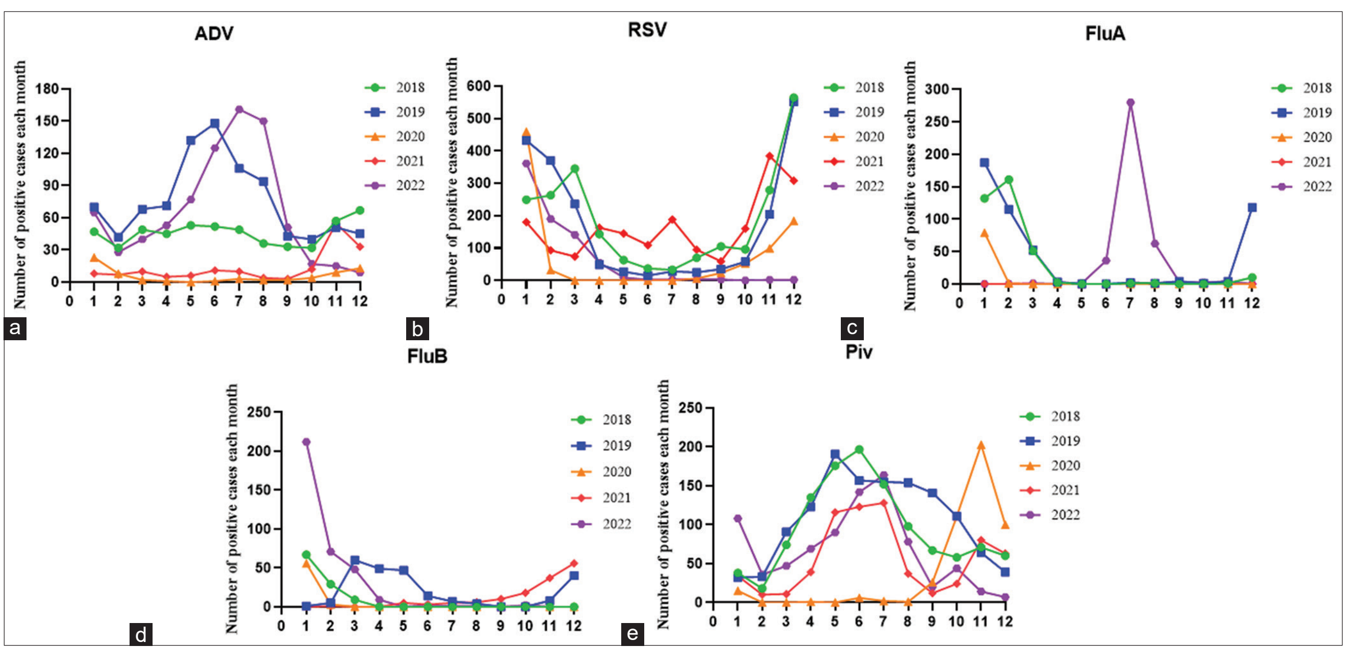

Figure 4: Distribution of respiratory pathogens in the different months between 2018 and 2022. (a) Adenovirus, (b) Respiratory syncytial virus, (c) FluA, (d) FluB, (e) Parainfluenza virus. ADV: Adenovirus, RSV: Respiratory syncytial virus, PIV: Parainfluenza virus, FluA: Infuenza virus A, FluB: Infuenza virus B

Table 4: Detection rates of five common respiratory viruses in children with acute respiratory infection in different seasons

Category	Number of cases	ADV (%)	RSV (%)	FluA (%)	FluB (%)	PIV (%)
Spring (March–May)	2018 (*n*=4647)	147 (3.16)	551 (11.86)	53 (1.14)	9 (0.19)	385 (8.28)
	2019 (*n*=4111)	271 (6.59)	312 (7.59)	55 (1.34)	156 (3.79)	405 (9.85)
	2020 (*n*=717)	3 (0.42)	0	0	0	1 (0.14)
	2021 (*n*=3093)	21 (0.68)	382 (12.35)	0	5 (0.16)	166 (5.37)
	2022 (*n*=4033)	170 (4.22)	205 (5.08)	2 (0.05)	57 (1.41)	206 (5.11)
	χ^2	204.87	250.41	115.60	270.40	149.71
	P	<0.001	<0.001	<0.001	<0.001	<0.001
Summer (June–August)	2018 (*n*=4437)	137 (3.09)	140 (3.16)	2 (0.05)	0	447 (10.07)
	2019 (*n*=4597)	348 (7.57)	68 (1.48)	3 (0.07)	25 (0.54)	466 (10.14)
	2020 (*n*=1384)	6 (0.43)	6 (0.43)	0	0	9 (0.65)
	2021 (*n*=3733)	25 (0.67)	392 (10.50)	0	14 (0.38)	288 (7.71)
	2022 (*n*=4284)	436 (10.18)	8 (0.19)	378 (8.82)	4 (0.09)	384 (8.96)
	χ^2	530.46	813.06	1066.55	41.67	141.06
	P	<0.001	<0.001	<0.001	<0.001	<0.001
Autumn (September–November)	2018 (*n*=4516)	122 (2.70)	480 (10.63)	1 (0.02)	0	196 (4.34)
	2019 (*n*=4347)	134 (3.08)	297 (6.83)	9 (0.21)	8 (0.18)	316 (7.27)
	2020 (*n*=2916)	15 (0.51)	174 (5.97)	0	0	340 (11.66)
	2021 (*n*=3110)	70 (2.25)	603 (19.39)	0	65 (2.09)	116 (3.73)
	2022 (*n*=1679)	83 (4.94)	5 (0.30)	9 (0.54)	2 (0.12)	78 (4.65)
	χ^2	93.50	609.17	29.67	170.30	230.36
	P	<0.001	<0.001	<0.001	<0.001	<0.001
Winter (December–February)	2018 (*n*=4540)	146 (3.22)	1076 (23.70)	303 (6.67)	96 (2.11)	116 (2.56)
	2019 (*n*=4645)	157 (3.38)	1353 (29.13)	420 (9.04)	46 (0.99)	104 (2.24)
	2020 (*n*=2890)	44 (1.52)	675 (23.36)	80 (2.77)	59 (2.04)	115 (3.98)
	2021 (*n*=2266)	48 (2.12)	581 (25.64)	0	57 (2.52)	107 (4.72)
	2022 (*n*=3141)	102 (3.25)	553 (17.61)	0	283 (9.01)	151 (4.81)
	χ^2	31.55	140.07	536.91	462.84	63.02
	P	<0.001	<0.001	<0.001	<0.001	<0.001

ADV: Adenovirus, RSV: Respiratory syncytial virus, FluA: Infuenza virus A, FluB: Infuenza virus B, PIV: Parainfluenza virus

geographical areas. On the other hand, boys tend to play together more often, causing respiratory infections.

The total detection rate of respiratory pathogens was 24.52%, with RSV virus having the highest detection rate, and there was a statistically significant difference in the detection rates of different pathogens. In addition, we observed statistically significant differences in the total detection rate of respiratory virus testing among different years and age groups. The positive detection rate was highest in 2019 and the 1–3-year-old age group,[21] which is prone to acute respiratory infections. RSV was the most common pathogen of ARI in children under 3 years old. The reason is considered to be due to the continuous improvement of the autoimmune system in older children, which considerably reduces the risk of infection. We also found that RSV had an obvious seasonal distribution and reached its peak in winter. ADV is mainly prevalent in spring and summer. FluA has a peak detection rate in winter. Winter and spring are the peak seasons for FluB infection, whereas PIV is detected in all seasons, with a higher incidence rate in spring and summer. The prevalence of various respiratory viruses varies seasonally, mainly due to changes in virus survival cycle, host response, and the interaction of multiple factors.[22] However, during the COVID-19 epidemic, the positive rate of various pathogens declined significantly, the prevalence of five respiratory viruses disappeared with seasonal changes, and the distribution of various pathogens was nearly uniform throughout the year.

Furthermore, we observed that an increase in infection rate of respiratory virus can be found in 2022. Respiratory virus activity resumed in 2022 but was lower than in 2018–2019 year before the COVID-19 pandemic. Despite NPIs are not pathogen specific, their use can also affect the spread of other infectious agents such as Flu. This effect is most prominently illustrated by the shortened in 2021 or even absent influenza season in 2020 compared with other years, which was delayed by the implementation of strict NPIs but rebounded in the end of 2021 after the stringency of these measures was lowered.[23] With the relief of the COVID-19, the restrictions were lifted or eased, offline classroom teaching and social dynamics return to normal in September 2021 in Wuhan. However, easing of COVID-19 restrictions has caused a comeback of respiratory virus infection diseases in 2022. Even if children are required to wear masks to school, it is difficult for children to use masks for effective prevention of respiratory virus infection, and experts do not recommend for children to wear masks for school sports activities. In addition, it is quite elusive to ensure the hand hygiene and mask compliance of primary school students. Schools are socially dense places, and children congregate in schools for a long time, increasing the risk of respiratory virus transmission. In addition, in March 2023, there was an outbreak of FluA in children in the Wuhan area which caused a wide variety of clinical symptoms. Individual influenza cases resulted in severe illnesses capable of inducing pneumonia and myocarditis that could progress to fulminant myocarditis and acted as a major causative agent for death and disability among children. Therefore, early identification and risk prediction of respiratory viruses are extremely important, timely analysis, and prediction of epidemic trends and characteristics. Early, rapid, and accurate diagnosis of pathogenic virus pathogens of respiratory viruses is essential to select of appropriate treatment.[24,25] This study is, however, not without limitations. First, it is important to note this was a retrospective case analysis with a limited sample size that was conducted at a single center, conclusions in other regions or hospitals may be different. In addition, multicenter studies are needed to expand the sample size and thus overcome one of the limitations of this study to control the infection of respiratory viruses. Second, there were a large number of respiratory pathogens discussed, and only a simple descriptive analysis of their prevalence was done. The next step needs to be a detailed discussion in combination with viral typing and viral coinfection, and this part can be supplemented and improved in subsequent studies to obtain more detailed epidemic results.

Conclusion

To sum up, our study further confirms that the public health protection measures adopted by the Chinese government can effectively control the transmission of various respiratory viruses among children. Perhaps documented more than for any other respiratory viruses, ADV, RSV, FLuA, FLuB, and PIV virus activity decreased markedly with the implementation of NPIs early in the COVID-19 pandemic. However, the resumption of global travel is likely to facilitate the spread and evolution of respiratory viruses. Analysis of the current status of respiratory virus epidemics in the past 5 years and continuous surveillance will help to prevent major outbreaks of respiratory virus infections after the epidemic.

Research quality and ethics statement

This study was approved by the Institutional Ethics Committee (2023IEC088). The authors followed applicable EQUATOR Network guidelines, i.e. STROBE Statement: Guidelines during the conduct of this research project.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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