

## SHORT COMMUNICATION

# Rhinovirus persistence during the COVID-19 pandemic—Impact on pediatric acute wheezing presentations

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## Abstract

Rhinoviruses have persisted throughout the COVID-19 pandemic, despite other seasonal respiratory viruses (influenza, parainfluenza, respiratory syncytial virus, adenoviruses, human metapneumovirus) being mostly suppressed by pandemic restrictions, such as masking and other forms of social distancing, especially during the national lockdown periods. Rhinoviruses, as nonenveloped viruses, are known to transmit effectively via the airborne and fomite route, which has allowed infection among children and adults to continue despite pandemic restrictions. Rhinoviruses are also known to cause and exacerbate acute wheezing episodes in children predisposed to this condition. Noninfectious causes such as air pollutants (PM<sub>2.5</sub>, PM<sub>10</sub>) can also play a role. In this retrospective ecological study, we demonstrate the correlation between UK national sentinel rhinovirus surveillance, the level of airborne particulates, and the changing patterns of pediatric emergency department presentations for acute wheezing, before and during the COVID-19 pandemic (2018–2021) in a large UK teaching hospital.

## KEYWORDS

epidemiology, horizontal transmission, human rhinovirus 1A, infection, pandemics, pathogenesis, respiratory tract, virus classification

## 1 | INTRODUCTION

One of the virological oddities during the COVID-19 pandemic has been the persistence—even the predominance—of rhinoviruses globally, in the absence of most of the other seasonal respiratory viruses (influenza, parainfluenza, respiratory syncytial virus (RSV), human metapneumovirus (hMPV)). Indeed, it is recognized that influenza and rhinoviruses compete, and the absence of influenza for the first 16–18 months of the pandemic (from March 2020) allowed rhinoviruses to become dominant in many parts of the world.<sup>1–3</sup>

Earlier studies on rhinoviruses have demonstrated their ability to transmit through aerosols,<sup>4,5</sup> which have been reiterated in more recent studies.<sup>6,7</sup> As nonenveloped viruses, rhinoviruses can survive longer on surfaces and resist alcohol-containing disinfectants, allowing effective fomite transmission.<sup>8,9</sup> This has likely helped rhinovirus to continue to propagate through populations despite the imposition of various pandemic masking, social distancing, and lockdown measures, as people still continue to mix when performing “essential” activities, like grocery shopping, some essential work duties, and any related childcare activities.<sup>10</sup>

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Another well-recognized characteristic of rhinoviruses is their ability to cause acute wheezing and exacerbations of asthma in children—a common winter season healthcare presentation in pediatric emergency departments (PEDs).<sup>11–13</sup> Such clinical wheezing can also be exacerbated by the inhalation of airborne particulate material in the  $\leq 2.5$  and  $\leq 10$   $\mu\text{m}$  diameter range ( $\text{PM}_{2.5}$ ,  $\text{PM}_{10}$ ).<sup>13–15</sup>

Here, we describe trends in PED presentations with acute wheeze, pre- and during the pandemic, and compare this to trends in national rhinovirus circulation and local concentrations of airborne particulates.

## 2 | METHODS

In this retrospective ecological study, we extracted the data of all children (aged 0 months to 18 years) presented to PED between January 2018 to December 2021, from the University Hospitals of Leicester NHS Trust. Children who were coded as “asthma” or “viral-induced wheeze (VIW)” by the clinicians as the first diagnosis in the PED were analyzed. These two terms are from the Emergency Care Data Set, a Systematized Nomenclature of Medicine Clinical Term compliant nationally mandated coding system.

Demographic data including age at presentation, ethnicity, and gender were extracted. The patient groups were further divided into under 5 years (aged 0 months to 5 years) and above 5 years (aged 5 years 1 month to 18 years) subgroups.

Contemporaneous air quality index (AQI) data were also obtained. The AQI is an index that reflects multiple air pollutants. As it is categorical

data, the monthly mean of AQI cannot be calculated. Instead, we used the monthly mean of the two main pollutants—particulate matter  $\leq 2.5$   $\mu\text{m}$  in diameter ( $\text{PM}_{2.5}$ ) and particulate matter  $\leq 10$   $\mu\text{m}$  in diameter ( $\text{PM}_{10}$ ). The data were obtained from the Department of Environment Food and Rural Affairs annual and exceedance statistic.<sup>16</sup>

The location for the  $\text{PM}_{2.5}$  data measurement was at the University of Leicester, which is assumed to be representative of the City of Leicester. The location for the  $\text{PM}_{10}$  data measurements was at the roadside of the Leicester section of the A594, representing Leicester's central distributor road network.

The levels of circulating respiratory viruses including rhinovirus, RSV, parainfluenza, hMPV, and adenovirus were obtained from the weekly national influenza and COVID-19 surveillance reports by Public Health England.<sup>17–19</sup> The values of weekly positivity for rhinovirus were obtained from the figures within these national surveillance reports (Supporting Information: Figures S4–S6).

## 3 | RESULTS

Table 1 shows the characteristics of the children presenting to PED with acute wheezing. The percentage of children according to age group, gender, and ethnicity did not differ much during 2018–2021, though the absolute numbers of such cases were 30%–50% lower across the different age groups in 2020.

Table 2 and Figure 1 show that the numbers of PED presentations for acute wheezing in 2020–2021 were very similar

**TABLE 1** Demographic data and number of PED presentations of children with acute wheezing in year 2018–2021

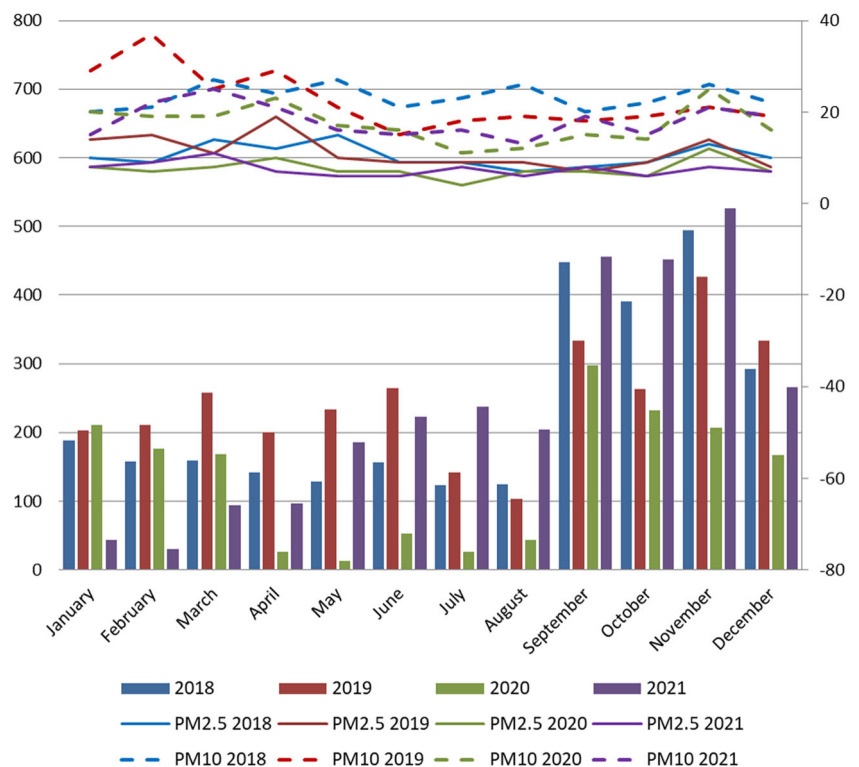
	2018	2019	2020	2021
Total number of PED presentations with acute wheezing, <i>n</i>	2805	2971	1622	2814
Male, <i>n</i> (%)	1748 (62)	1841 (62)	1023 (63)	1713 (61)
White British, <i>n</i> (%)	1337 (48)	1420 (48)	743 (46)	1340 (45)
BAME, <i>n</i> (%)	1139 (41)	1211 (41)	663 (41)	1147 (41)
Mixed White and other White background, <i>n</i> (%)	301 (11)	307 (10)	179 (11)	290 (10)
Not stated, <i>n</i> (%)	28 (1)	33 (1)	37 (2)	37 (1)
PED presentations of children under 5, <i>n</i>	2069	2096	1035	1942
White British, <i>n</i> (%)	1060 (51)	1071 (51)	502 (49)	1007 (52)
BAME, <i>n</i> (%)	767 (37)	778 (37)	385 (37)	707 (36)
Mixed White and other White background, <i>n</i> (%)	229 (11)	227 (11)	128 (12)	200 (10)
Not stated, <i>n</i> (%)	13 (1)	20 (1)	20 (2)	28 (1)
PED presentations of children over 5, <i>n</i>	736	875	587	872
White British, <i>n</i> (%)	277 (38)	349 (40)	241 (41)	333 (38)
BAME, <i>n</i> (%)	372 (51)	433 (49)	278 (47)	440 (50)
Mixed White and other White background, <i>n</i> (%)	72 (10)	80 (9)	51 (9)	90 (10)
Not stated, <i>n</i> (%)	15 (2)	13 (1)	17 (3)	9 (1)

Abbreviations: BAME, Black, Asian, and minority ethnicity; PED, pediatric emergency department.

**TABLE 2** Total number of all PED presentations, the number of PED presentations with acute wheezing, and the monthly mean of particulate matter less than 2.5  $\mu\text{m}$  ( $\text{PM}_{2.5}$ ) and mean of particulate matter less than 10  $\mu\text{m}$  ( $\text{PM}_{10}$ ) between years 2018 and 2021<sup>16</sup>

	Total number of all PED presentation, <i>n</i>				Number of PED presentations with acute wheezing, <i>n</i>				Monthly mean $\text{PM}_{2.5}$ ( $\mu\text{g}/\text{m}^3$ )				Monthly mean $\text{PM}_{10}$ ( $\mu\text{g}/\text{m}^3$ )			
	2018	2019	2020	2021	2018	2019	2020	2021	2018	2019	2020	2021	2018	2019	2020	2021
January	4303	5268	5177	2613	189	203	211	43	10	14	8	8	20	29	20	15
February	4039	5157	4854	2563	158	211	177	30	9	15	7	9	21	37	19	22
March	4515	6191	4119	4103	159	257	169	94	14	11	8	11	27	25	19	25
April	4583	5532	1758	4675	142	200	26	97	12	19	10	7	24	29	23	21
May	4967	5357	2489	5838	129	234	13	186	15	10	7	6	27	21	17	16
June	4775	5238	2723	6268	156	264	53	223	9	9	7	6	21	15	16	15
July	4539	4835	2916	5403	123	142	26	237	9	9	4	8	23	18	11	16
August	4085	4459	3349	5029	124	103	43	204	7	9	7	6	26	19	12	13
September	5087	5575	4207	7046	448	334	298	456	8	7	7	8	20	18	15	19
October	5470	5396	3781	5898	391	263	232	452	9	9	6	6	22	19	14	15
November	6561	6400	3633	6149	494	426	207	526	13	14	12	8	26	21	25	21
December	5986	6693	3127	4831	292	334	167	266	10	8	7	7	22	19	16	19

Abbreviation: PED, pediatric emergency department.

**FIGURE 1** Monthly number of pediatric emergency department (PED) presentations due to acute wheezing, the monthly mean of particulate matter less than 2.5  $\mu\text{m}$  ( $\text{PM}_{2.5}$ ), and monthly mean of particulate matter less than 10  $\mu\text{m}$  ( $\text{PM}_{10}$ ) between years 2018 and 2021. Columns indicated by red triangle arrows indicate the periods (April–August 2020, November 2020, January–March 2021) where the number of PED presentations decreased substantially compared to the same months in previous years.

to those in 2018–2019 in the same months—except for April–August 2020, November 2020, and January–March 2021. There was also a drop in the number of all PED presentations between March 2020 and February 2021.

The levels of airborne environmental particulates ( $\text{PM}_{2.5}$  and  $\text{PM}_{10}$ ) did not vary significantly during 2018–2021 for April–July

(one-way analysis of variance:  $\text{PM}_{2.5}$ ,  $p$  value = 0.08;  $\text{PM}_{10}$ ,  $p$  value = 0.12) (Table 2, Supporting Information: Figures S1–S4).

Our local virology laboratory ceased all routine testing for seasonal respiratory viruses during this period to cope with the SARS-CoV-2 testing in the first wave of the COVID-19 pandemic. However, national sentinel surveillance testing for seasonal respiratory

viruses continued, with data available from Public Health England (PHE) surveillance reports during 2018–2021 (Supporting Information: Figures S5–S7).<sup>17–19</sup>

These national reports showed that during 2020 and early 2021, the other common seasonal respiratory viruses (influenza, RSV, parainfluenza virus, hMPV) were mostly completely absent, except for a persistent low-level background of adenovirus. There was an ongoing, though the fluctuating incidence of rhinovirus. Although there is a discontinuity in the PHE surveillance reports (Supporting Information: Figure S5) for rhinovirus during weeks 15–26 (April–July) 2020, the incidence trend of rhinovirus during this period appears to be relatively low. Figure 2 shows that the variation of rhinovirus incidence approximately correlated to the number of PED presentations with acute wheeze.

Once the national lockdown restrictions were eased in March 2021, the incidence of other seasonal respiratory viruses increased, particularly parainfluenza (week 15–31 of 2021), RSV (week 23 of 2021 to week 3 of 2022), and hMPV (week 39 of 2021 to week 3 of 2022) (Supporting Information: Figure S7).

## 4 | DISCUSSION

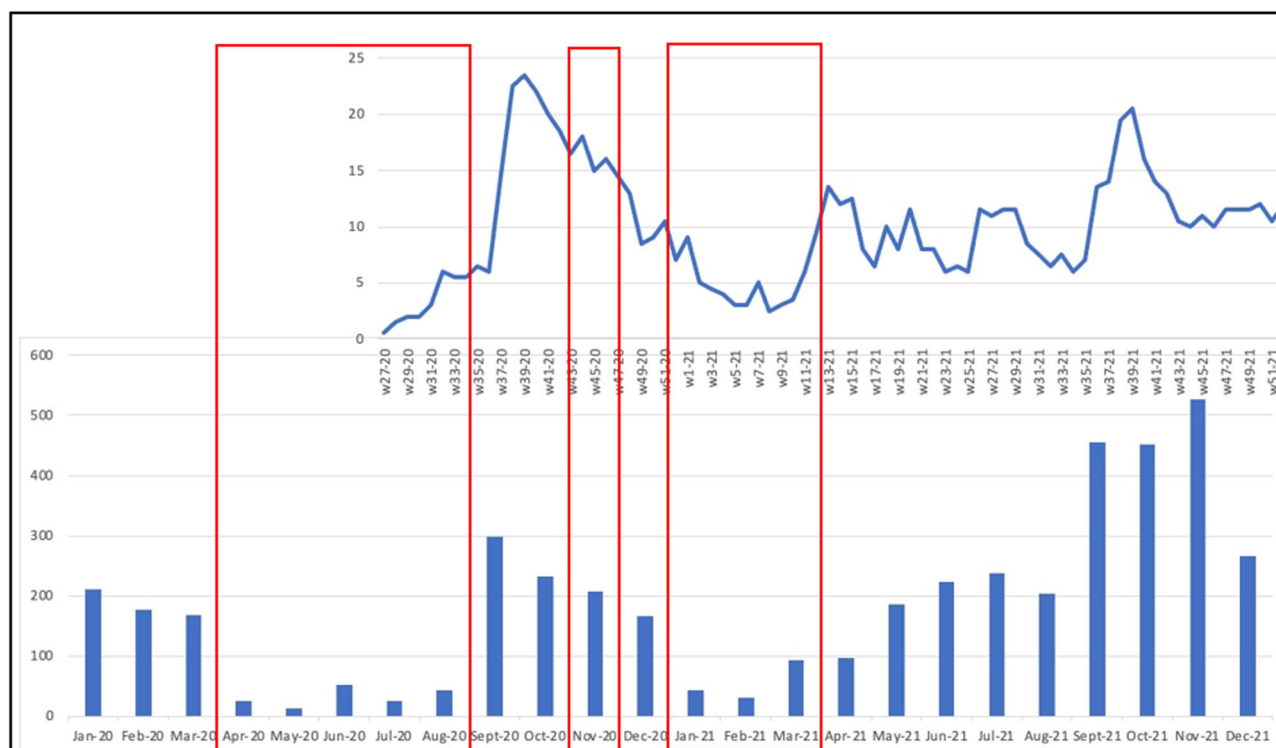
These study findings suggest that the primary reason for the drop in the number of PED presentations for acute wheezing during April–August 2020, November 2020, and January–March 2021

(compared to the same periods in 2018–2019) is a decrease in the national incidence of rhinovirus over these periods. These periods correlated with the imposition of national and local lockdown measures (first national lockdown March 26, 2020 to March 23, 2020, local lockdown in Leicester, July 4, 2020 to August 31, 2020, second national lockdown November 5, 2020 to December 2, 2020, and third national lockdown January 6, 2021 to March 8, 2021).<sup>20</sup> During these periods, strict containment measures were imposed which required everyone to stay at home, except for a limited number of circumstances such as essential shops and work. Schools, children's playgrounds, and parks were closed.

Based on the contemporaneous plots of PM<sub>2.5</sub> and PM<sub>10</sub> (Supporting Information: Figures S1–S4), these airborne particulates appeared to have played no role in this decrease. Similar findings were reported in a US study, where a decrease in asthma-related healthcare utilization was more closely linked to a decrease in circulating rhinovirus rather than changes in airborne pollutants.<sup>21</sup>

The persistence and dominance of rhinoviruses during the COVID-19 pandemic suggests that the social distancing restrictions applied during the lockdown were more effective in suppressing the other seasonal respiratory viruses than rhinoviruses.<sup>22,23</sup>

Other reasons for a reduction in PED attendances for recurrent wheezing during the pandemic lockdown periods could include more home-schooling with less social contact with other children (most schools closed during national and local lockdowns). This reduced



**FIGURE 2** Monthly number of pediatric emergency department presentations due to acute wheezing during January 2020 to December 2021 and the weekly positivity for rhinovirus according to UK sentinel laboratory surveillance (Supporting Information: Figures S5–S7). The boxes defined by the red line indicate the periods (April–August 2020, November 2020, January–March 2021) where the pandemic lockdown restrictions were implemented as discussed in the main text.

mixing would have reduced the exposure to both seasonal respiratory viruses as well as other outdoor allergens. Staying at home could also have improved compliance with preventative medication.<sup>24</sup> Health-seeking behavior had also changed during the pandemic, as fear of COVID-19 led to fewer hospital presentations.<sup>25,26</sup>

As an ecological study, this study has some limitations. The causal relationship between the drop in PED presentations and circulating rhinovirus could not be drawn on an individual level, and thus more individual-based observational studies might be required. The data for rhinoviruses were obtained from national sentinel surveillance testing due to the cessation of local laboratory testing for respiratory viruses, though we note that some weeks of surveillance data were not available. As such, the assumption was made that local rhinovirus prevalence correlated with the national data. Besides, other factors that might cause a reduction in PED attendances could not be strictly excluded.

In summary, COVID-19 pandemic lockdown measures reduced the incidence of rhinoviruses and other seasonal respiratory viruses, globally, which were correlated with reductions in PED presentations for acute wheezing. The level of airborne pollutants (PM<sub>2.5</sub> and PM<sub>10</sub>) showed little correlation with this trend in acute wheezing during the pandemic.

#### AUTHOR CONTRIBUTIONS

The study was conceived by Kah Wee Teo, Damian Roland, and Erol A. Gaillard. Kah Wee Teo, Deepa Patel, and Shilpa Sisodia collated and curated the data. These data were reviewed and analyzed by Kah Wee Teo and Julian W. Tang who also drafted the first version of manuscript. Further editing and revision was performed by all authors, before submission.

#### CONFLICT OF INTEREST

The authors declare no conflict of interest.

#### DATA AVAILABILITY STATEMENT

All the data are shown in the manuscript and/or are publicly available on government websites (the national respiratory virus surveillance data). All data are available upon reasonable request.

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#### SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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