Changes in Respiratory Syncytial Virus seasonality during the SARS-CoV-2 pandemic

Jan Gumathi Bormin[1]: Conceptualization, Investigation, Methodology, Project administration, Visualization, Writing; **Yvette N. Löwensteyn**[2,#]: Conceptualization, Methodology, Supervision; **Marie-Noelle Billard**[2,#]: Conceptualization, Methodology, Supervision.

[1] Msc Student Infection and Immunity at Utrecht University: Heidelberglaan 8; 3584 CS Utrecht; The Netherlands
[2] Group Bont; University Medical Center Utrecht, Utrecht University, 3584 CX Utrecht, The Netherlands
Direct supervisor
Correspondence should be addressed to J.G.B (J.JanGumathiBormin@students.uu.nl)

Abstract

In response to the COVID-19 pandemic countries all over the world implemented non-pharmaceutical interventions (NPIs) like closing schools, non-essential businesses, and enforcing a curfew. In this period, the seasonality of human respiratory syncytial virus (RSV) was significantly changed. Countries where NPIs were implemented at the end of the RSV season saw an expedited end, with significantly faster reduction in RSV cases. Subsequently, the following 2020-2021 RSV season either did not happen (within the expected time frame) or was delayed with 8 – 12 weeks. Countries with a skipped seasonal RSV epidemic generally experienced an out-of-season RSV epidemic, where a RSV peak was noted 20 to 37 weeks after the usual epidemic. The average age of children infected during these peaks was significantly older but the course of the disease was less severe. Notably, the inter-seasonal RSV resurgence generally did not happen after schools reopened, which did happen with the rhinovirus. This RSV resurgence often happened after most NPIs were let go and adults and adolescent could mingle and move about more freely. This indicates that adults and adolescent might be a RSV reservoir and warrants more research. If the COVID-19 pandemic forces implementations of new long lasting NPIs health care systems and authorities should prepare for both on- and out-of-season RSV epidemics.

Introduction

The human respiratory syncytial virus (RSV) is a single-stranded non-segmented negative-sense enveloped RNA virus.[1] RSV is a globally prevalent virus that mostly affects children under the age of 5[2–5], immune compromised adults, and elderly.[6] Infants infected by RSV can lose acquired immunity to the virus before the new season starts, making them a target once more.[7–9] As their immune system matures the protection against RSV improves.[10,11] It was estimated that in 2015, 22% of all acute lower respiratory infections in children younger than 5 were associated with RSV and developing countries carry the heaviest burden with 99% of all RSV-associated deaths.[12]

Respiratory syncytial virus has a consistent seasonality, starting in the southern hemisphere and moves to the north.[13,14] In temperate climates RSV season lasts 5-6 months and peak viral activity is mostly seen in the winter months.[13] In the tropical climate around the equator there is a significant temporal difference in onset of RSV epidemic. Where on the northern hemisphere of the tropics RSV epidemics start in July, while on the southern part the onset is in January.[14] For countries near the equator and tropical regions with humid or rainy season the RSV season can last up to 10 months.[13]

In the end of 2019 the world was introduced to a novel virus, SARS-CoV-2.[15] This new virus quickly spread from Wuhan, China to the rest of the world[16,17] and on March 11 the WHO characterized COVID-19 as a pandemic.[18] Initially, there were no vaccines available to combat the virus so the world retaliated with large scale non-pharmaceutical interventions including hand hygiene, face masks, improved ventilation, restriction in traveling, and social distancing measurements.[19,20]

However, non-pharmaceutical interventions (NPIs) do not specifically target one virus but influence the transmission of all kinds of pathogens. The goal of this study is to describe the seasonality of the human respiratory syncytial virus during the SARS-CoV-2 pandemic.

Methods

Search Strategy and Screening Criteria

This study is a literature review for which a systemic search was performed on 29th of November 2021 using the following databases: PubMed, Scopus, and Web of Science. The search terms used are detailed in sup. table 1.

All articles that reported on RSV seasonality during the COVID-19 pandemic in 2020-2021 were included. RSV seasonality was defined as the course of RSV throughout a year or portion of the year where the RSV virus is especially active. Articles were excluded if: they described or compared the seasonality of RSV using only data preceding the SARS-CoV-2 outbreak; if they did not specify RSV but compiled the data of multiple respiratory pathogens or health outcomes; if the report did not examine the seasonality if the virus but, e.g., looked at the numbers on a certain time point.

Results

Search results

The systematic literature search identified 839 unique articles and after exclusion based on article type, species, language, subject, and availability, 114 were successfully retrieved. Subsequent screening of full text resulted in the exclusion of 29 articles due to not specifying RSV, describing a time period outside of the COVID-19 pandemic, not describing RSV seasonality. 84 articles were included in this review with 15 studies originating from North America, 2 from South America, 10 from Oceania, 23 from Asia, 26 from Europe, 1 from Africa, 2 from the Middle East (including Turkey), and 5 without a specific location. See sup. Fig. 1 and sup. table 2 for the flow diagram and search results.

The 2020 RSV seasonal peak was first absent in the southern hemisphere

In Brazil, researchers looked at the presence of RSV in two general hospitals from mid-May to September. A month earlier schools and daycare centers were closed to halt the spread of COVID-19. The RSV season in Brazil normally last from February to July, with a peak in April.[13] But out of the 1435 tested subjects (1137 adults and 298 children), the researchers found zero cases of RSV.[21] In Bolivia, Chile, Colombia, and Uruguay something similar happened, where hospitals noted a 92% reduction in RSV-related paediatric intensive care unit (PICU) admissions in 2020, when compared to 2018 and 2019.[22]

Researchers in South Africa, on comparable longitude with South America, did report a RSV peak within the expected time period but it was significantly reduced in both numbers and time span, when compared with the mean cases of 2013 – 2019.[23] The median (2013-2019) starting week of RSV seasonality in South Africa is week 2 but in 2020 it started in week 9 and ended in week 15, while the closure of non-essential business, schools and nation-wide stay-at-home orders were implemented in week 12.[23]

Academics in Australia noted that in the first 13 weeks of 2020, RSV cases followed a comparable trend as previous years. But on onwards from week 14, when the COVID-19 restrictions were implemented, a sharp decrease in RSV cases was noted and no seasonal RSV peak occurred.[24–31] Neighbouring New Zealand showed comparable data, where pre-lockdown (1 January – 24 March) an average reduction of 22.7%, compared to the 5 previous years, was noticed.[32,33] During lockdown the RSV numbers decreased significantly and fast and even when measurement were reduced to their minimum, RSV did not return.[33]

No 2020-2021 RSV season in Asia, except in China

In South-Korea, NPIs were implemented early February 2020, the seasonal RSV epidemic was already over but researchers documented an accelerated decrease in RSV numbers.[34] A 81 to 100% reduction in RSV cases were accounted during subsequent RSV season, which would normally start in November.[34,35] In Japan, the yearly RSV epidemic normally starts end of summer/early autumn. Japanese authorities requested closures of schools early March 2020 and declared a state of emergency first week of April, which was lifted end of May 2020, a week later schools reopened. Researchers saw that RSV numbers dropped early March and there were no outbreaks across 2020 and an overall decrease of ~85% in RSV cases throughout the year[36–45], scholars in Tokyo even reported an 97.9% decrease in RSV activity during the NPIs.[36]

Authorities in Thailand implemented NPIs end of March and researchers measured close to zero RSV-positive samples in the 2020 RSV nominal seasonal timeframe, but also significantly less testing was done due to children being homebound.[46]

In China, NPIs were also enforced at the end of the RSV season (in January, 2020) and data from hospitals showed an accelerated end of the RSV season.[47–50] Major NPIs like work and school suspension were ended in August 2020 after which different RSV epidemic patterns were noticed. Some hospitals published data showing the subsequent RSV season starting on time with an expected, regular, progression.[51–53] Another hospital reported significantly lower percentage of RSV, but within the seasonal months.[54] Yet other hospitals recorded a higher percentage of RSV positive patients.[55,56]

RSV was almost non-existent during the 2020-2021 season in Turkey and Israel

Around the Middle-East the lack of seasonal RSV was also noticed, where researcher in both Turkey[57] and Israel[58] reported significantly lower RSV numbers. The hospital in Israel recorded zero RSV cases throughout the 2020-2021 RSV season.[58]

North America noted an expedited end of 2019-2020 season and no seasonal peak in 2020-2021

In the United States the national emergency, to which many states responded with NPIs, was declared on the end of the RSV season (mid-March) but still resulted in a decrease of RSV levels, compared with the previous seasons.[59–67] In states where RSV persisted throughout the year, like Florida, RSV prevalence was reduced to near zero.[67] In the state of Alaska, after the NPIs were implemented, the acute respiratory infections related hospitalization dropped to zero, 8 weeks earlier than customarily.[68] The northern neighbour Canada showed a similar trajectory, where NPIs introduced in week 11 of 2020 expedited the end of RSV season.[69–72] And just as it was seen in the US, there was no subsequent epidemic and 2020 stayed virtually RSV-free for Canada.[69–71]

Available data shows that Europe did not experienced a seasonal RSV epidemic in 2020-2021

In Europe similar patterns were observed. Researchers in Spain noted a significant decrease in seasonal RSV related acute bronchiolitis hospitalization[73,74], and in Belgium there were only 20 RSV cases registered halfway through the seasonal peak, a >99% reduction.[75] Scholars in the United Kingdom[76,77] and Austria[78] also reported an reduction in RSV incidence in patients and cases, respectively. Switzerland started to implement NPIs in March 2020, the end of their RSV season and subsequently experienced no start of the new RSV season in October 2021[79], hospitals in Germany[80,81] noticed similar patterns. Finland also introduced NPIs at the end of 2019-2020 RSV season expediting the end[82–84] and experienced no start of 2020-2021 season.[82] In Italy the introduction of NPIs was also followed by an expedited end of RSV season 2019-2020[85,86] and no onset of 2020-2021 RSV season.[87–91]

Throughout the world RSV resurged inter-seasonally

In France something different was observed. The first lockdown was implemented at the very end of the 2019-2020 RSV season (end March), further reducing the already low RSV cases.[92,93] A second lockdown was issued in November 2020 when normally a RSV season would be well underway – but barely any RSV was measured.[92–95] This second lockdown was followed with school holidays and in February RSV numbers started to increase, where in previous seasons RSV numbers would be decreasing. These rising numbers resulted in an RSV epidemic, starting in March 2021, 4 months delayed.[92,93,96] The second national lockdown in France lasted from week 45 to 50 (2020) but they kept nurseries and schools open, so when the delayed RSV epidemic started schools were already open for months.[92–94] Researchers couldn't correlate the new RSV epidemic with any major changes in NPI strategy.[92]

Iceland reported an 8 week delay in RSV seasonality, weeks after their last holiday.[97] In Switzerland RSV numbers grew significantly in April 2021, where it would normally start in November. Just like in France and Iceland, the schools and day-care centres in Switzerland were not closed in the autumn and winter of 2020.[79]

In the United States, New York[64] and Houston[62] both experienced 6 month delayed RSV peak. In Houston, no seasonal RSV was detected even when schools opened in September, but when all NPIs were eliminated in March, RSV rose interseasonally.[62]

Table 1. **Changes in RSV seasonality per country.** Countries are grouped and colored per geographical location: South America, Southern Africa, Oceania, Asia, Middles East, North America, and Europe.

Countries	Nominal RSV season start-peak-end	Part of season evaluated	Onset NPIs	Relative reduction in cases	Seasonal Peak?
Brazil	February – April – July[13]	Mid-May to September, 2020[21]	Mid-March, 2020[21]	100%[21]	No 2020 seasonal RSV epidemic*
Bolivia, Chile, Colombia, and Uruguay	March/April – July – August/September[13,22]	January to August, 2020[22]	N/A	92%[22]	No 2020 seasonal RSV epidemic*
South Africa	February – March – May[13,23]	January – Mid October, 2020[23]	Mid-March[23]	~33%[23]	Significantly reduced
Australia	May – July – August[13]	2020-2021	April - May[26,28,29] East Australia also in July & August[27,29,31]	89%[27]-94%[25]-98%[26]	No seasonal 2020 RSV epidemic
New Zealand	May – July/August - September[13]	January – 27 September[32,33]	25 March – 27 September	81.2-98%[33]	No 2020 seasonal RSV epidemic*
South Korea	August/October – Mid-October/November - December[13]	2020-2021 [34,35]	February/March	81 – 100%[34,35]	No seasonal 2020-2021 RSV epidemic
Japan	August/September – October/November – December[13]	2020-2021	March, 2020	85%[45]-90%[43]-93.5%[41]	No seasonal 2020-2021 RSV epidemic
Thailand	April/May – September – November[13]	2020-2021[46]	End of March	N/A	No seasonal 2020-2021 RSV epidemic
China	November – December/February – April[13]	2020-2021	January/February 2020	Not significantly different[51]	2019-2020 season ended early. Regional differences in 2020-2021 season
Turkey	October – January - April	March 2020 – Feb 2021	Mid-March	88%[57]	No seasonal 2020-2021 RSV epidemic
Israel	November – December/January - February[13]	2020-2021	Early March	100%[58]	No seasonal 2020-2021 RSV epidemic
United States	November – January - March[13]	2020	Mid-March	64% (at start of NPI period, 2019-2020 season)[65], ~90% 2020-2021 season[66]	2019-2020 season ended early, No seasonal RSV epidemic in 2020-2021 season
Canada	November – January/February - March[13]	2020-2021 season	Mid-March	~98%[71]	2019-2020 season ended early, no seasonal RSV epidemic in 2020-2021
Spain	November – December - February[13]	November – February	March	86%[73]	No seasonal 2020-2021 RSV epidemic
Belgium	September/October – December - February[13]	September – January	Mid-March	>99%[75]	No seasonal 2020-2021 RSV epidemic*
UK	October – December - February[13]	Until February 2021	Mid-March	N/A	2019- 2020 season ended early
Switzerland	October – January - April[79]	Until July 2021	Mid-March	>95%[79]	No seasonal 2020-2021 RSV epidemic
Germany	November/December – December/January – February/March[13]	Until March[81] and April[80], 2021	Mid-March	100%[80,81]	No seasonal 2020-2021 RSV epidemic
Austria	January – March - April[78]	Until June 2020[78]	Mid-March	77%[78]	2019-2020 season ended early, no seasonal RSV epidemic in 2020*
Finland	December/January – February/March – April/May[13]	Until February 2021	Mid-March	N/A	Ended earlier, no onset of 2020/2021 season
Italy	October – January/February – April/May[13]	2020-2021	Early March	98%[89], 99%[87], 100%[88]	No seasonal 2020-2021 RSV epidemic
France	October/November – December – February/March[13]	2020-2021	Early March	N/A	No seasonal 2020-2021 RSV epidemic, 12 weeks shift of peak

* = data or research doesn't completely cover the complete RSV season.

In Ashdod, Israel, the start of the RSV epidemic was delayed 30 weeks, starting 15 weeks after schools started to reopen.[58]

Japan saw an exceptionally long delay where the 2021 RSV season started in January, 37 weeks later than usual.[39,44] Due to COVID-19 the Japanese government declared a state of emergency from January 13 to March 21 (2021) and April 25 to June 20 (2021) but RSV number rose, seemingly unbothered.[39] In Thailand RSV resurged ~10 weeks later than accustomed, around 7 weeks after schools reopened.[46]

South Africa experienced two RSV peaks, the first one happened during the expected period, even though the peak was significantly smaller both in width (time) and height (cases).[23] The second peak occurred 20 weeks after the first and interestingly did start to develop when schools started to re-open.[23]

Australia experienced a major RSV epidemic in their summer, 6 months later than average. In West Australia schools were operating normally for 20 weeks before RSV numbers rose rapidly.[28] In south east Australia, schools were opened in stages from week 38 and RSV numbers rose sharply after school holidays (week 51-3) when schools fully returned to onsite learning.[29]

The out-of-season peak was often bigger

The delayed peak in France was smaller than previous peaks[92,93], except for Paris where more patients were admitted for RSV related acute lower respiratory infection.[94] The delayed RSV epidemic in Iceland was significantly higher than previous season, with the peak being four-fold higher.[97] Importantly, the amount of testing in Iceland was increased with 21%.[97]

The out-of-season peak measured in a hospital in Israel was higher in terms of weekly cases count and total incidence.[58]

In South Africa the second peak was developing similarly as an average seasonal peaks did, showing comparable percentage of RSV patients.[23] In the Australia, the sudden December peak contained almost double the amount of RSV positive patients, when compared to the seasonal peak in July of the past 8 years.[28–30]

The patient in the delayed peaks were often older children

France reported a higher median age for children infected with RSV but also reported less adults being positive for the virus.[92–94] A higher median age was also seen in Iceland, where the median age in the delayed peak was 16 months while in the previous five RSV season the median age was 5.7 months, the researchers also reported three times as much RSV positive 1-2 year-olds.[97]

Researchers from New York noted that the median age of RSV related hospital admission increased from 6 months to 17 months.[64]

In contrast to other reports, researchers in Israel saw no difference in age.[58]

In South West Australia the median age of positive RSV cases increased with 1.8 month[29] but the median age in West Australia doubled.[28,30]

Course of the RSV was often significantly less severe

Patients in the delayed RSV peak in France were less sick when compared to earlier peaks, with shorter hospital stays, less ICU admissions, and less severe treatment like oxygen or antibiotic treatment.[92,94] Even though the out-of-season peak in Iceland was four times higher than previous season, RSV-related hospital admissions were approximately half the number of earlier seasons.[97]

A similar pattern was observed in a New York hospital, where length of hospital stay decreased from 4 days to 3 days and ICU admission were significantly reduced from 81% to 45% of the patients.[64]

Table 2. Inter-seasonal resurgence of RSV per country. Countries are grouped and colored per geographical location: Europe, North America, Middle East, Asia, Southern Africa, and Oceania.

Country	Delay	Peak	Age distribution
France	16 weeks[92–94]	Less patients and less severe patients[92–94]	Less adults, more relative older children (2-5 year old)[92–94]
Iceland	~8 weeks[97]	Four-fold higher peak but less hospital admissions[97]	Median increased from 5.7 to 16 months[97]
Switzerland	~20 weeks[79]	Incomplete data on peak height, no data on severity	No comparison with previous epidemics
United States	20-25 weeks[62,64]	Shorter hospital stay and significant less ICU admissions	Median increase from 6 month to 17[64]
Israel	~30 weeks[58]	More severe, more ICU admissions, Incomplete data[58]	N/A
Japan	~37 weeks[39,44]	Incomplete data on peak height, no data on severity	N/A
Thailand	~10 weeks[46]	N/A	N/A
South Africa	20 weeks (second peak)[23]	Incomplete data on peak height, no data on severity	N/A
Australia	25 weeks[28–30]	Almost double when compared to average seasonal peak[28–30], no difference in illness severity[30]	Median age increased with 1.8[29] - 8.3 months[28,30]

In Ashdod, Israel, the percentage of RSV related ICU admission rose from 21 to 30% but length of stay did not change.[58] When the data from the Ashdod hospital were published, the delayed RSV epidemic was still underway so data are not complete.

Researchers in Western Australia noted that severity of illness and requirement of ICU was not significantly different during the inter-seasonal peak but length of stay was significantly shorter.[30]

Discussion

The aim of this study is to describe the seasonality of the human respiratory syncytial virus during the SARS-CoV-2 pandemic. Our systematic literature search retrieved data from 25 countries worldwide.

A global pattern was that major NPIs resulted in expedited end of RSV season, often the subsequent expected RSV epidemic would pass over with little to no cases. If a major lockdown was implemented in a period between two RSV seasons, the second would also pass over. What often happened next was an out-of-season RSV epidemic, the timing could vary vastly ranging from 8 to 30 weeks. Interestingly, this inter-seasonal RSV epidemic often did not occur when schools reopened but did occurred when general public life returned to pre-COVID standards, as was seen in, among others, the US, Israel, Switzerland, France, and Australia.[28,29,58,62,79,92] This indicates that adults and adolescents might be a RSV reservoir[26] and calls for a re-evaluation of the cause of RSV epidemics.

In France and Iceland there were schools holidays during the inter-seasonal RSV resurgence and a drop in RSV numbers were noted.[92,97] A similar effect was observed before the COVID-19 pandemic, when, in February 2019, schools and workplaces were closed in Washington State, US, due to extreme winter weather. This closing occurred during the RSV epidemic and a significant drop in RSV cases was measured.[98] Thus, although opening of schools might not trigger the start of a RSV epidemic, school-restricting NPIs do seem to help reduce an ongoing RSV epidemic.

But these patterns are not always consistent. In Japan strict NPIs were enforced from January 13 to March 21 (2021) and from April 25 to June 20 (2021), schools being exempt[39]. Those measurements, and the time in between, seem to had little effect on the growing number of RSV infections.[39,44] So as researchers noted earlies, it is very difficult to correlate inter-seasonal RSV peaks with any major changes in NPI strategies.[92]

Researchers that described the delayed RSV epidemic often noted that the average age of the patient was considerably higher than during pre-COVID RSV epidemics, but the course of the disease was significantly less severe, with less patients requiring ICU admission or major treatments.[28–30,64,92–94,97]

Interestingly, not all respiratory viruses got significantly disrupted after NPI implementations. Especially the rhino- and enteroviruses continued their yearly cycle with initially decreased numbers but those quickly returned to their normal numbers, as was seen in the US.[61,66] In Australia[24,31], South Korea[34], China[54,55], Japan[38], Thailand[46], Austria[78], and Turkey[57] rhinovirus numbers were significantly higher than average, after the initial dip. Interestingly, the resurgence of rhinovirus in these countries was immediately preceded by schools opening. Researchers linked these discrepancies to the fact that rhinoviruses can be transmitted by aerosol, direct contact, indirect contact through objects, and the reduced effect of surgical masks on rhinovirus detection in droplets or aerosols.[31,61,66] The lack of competition or interference from other viruses and increased testing for mild symptoms were also mentioned as cause of increase rhinovirus detection.[24,31]

This study has several limitations. Some of the included studies used data sets that did not include the complete 2020-2021 RSV season but lacked either the start or the end.[33,75,78] Also, some of the data from the inter-seasonal RSV epidemics were incomplete, where only the rise of this RSV epidemic was discussed[23,39,44,79]. Some of the data sets originated from a few hospitals or laboratories, which may not be representative of an ongoing epidemic, or lack thereof, in a whole country.[21,57,58] Furthermore, this study focusses on the onset of NPIs during the 2019-2020 COVID-19 pandemic, while there may be other factor that also influence the seasonality of respiratory viruses. For example, researchers suggested that a lack of RSV re-exposure resulted in a decreased or waning immunity in children previously infected[30,31,64,97] and a new population of immunologically naïve children.[26,96,97]

Several researchers warned for inter-seasonal resurgence after the initial absence of seasonal RSV epidemics.[99–101] Researchers from the US built and ran simulations that showed that longer NPIs resulted in a larger RSV outbreak, after which the seasonality eventually returned to pre-NPI status.[67] A mathematical model was also made in Japan and gave a similar prediction.[36] Health care systems and authorities should be aware of the effect of NPIs on other viruses. If long lasting NPIs are required these administrations should prepare for out-of-season outbreaks but also on-season outbreaks as these could be of greater magnitude.[102,103] A good example is the Swiss national clinical-led reporting system that was able to demonstrate regional and national RSV dynamics.[79]

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Conflict of interest

None declared.

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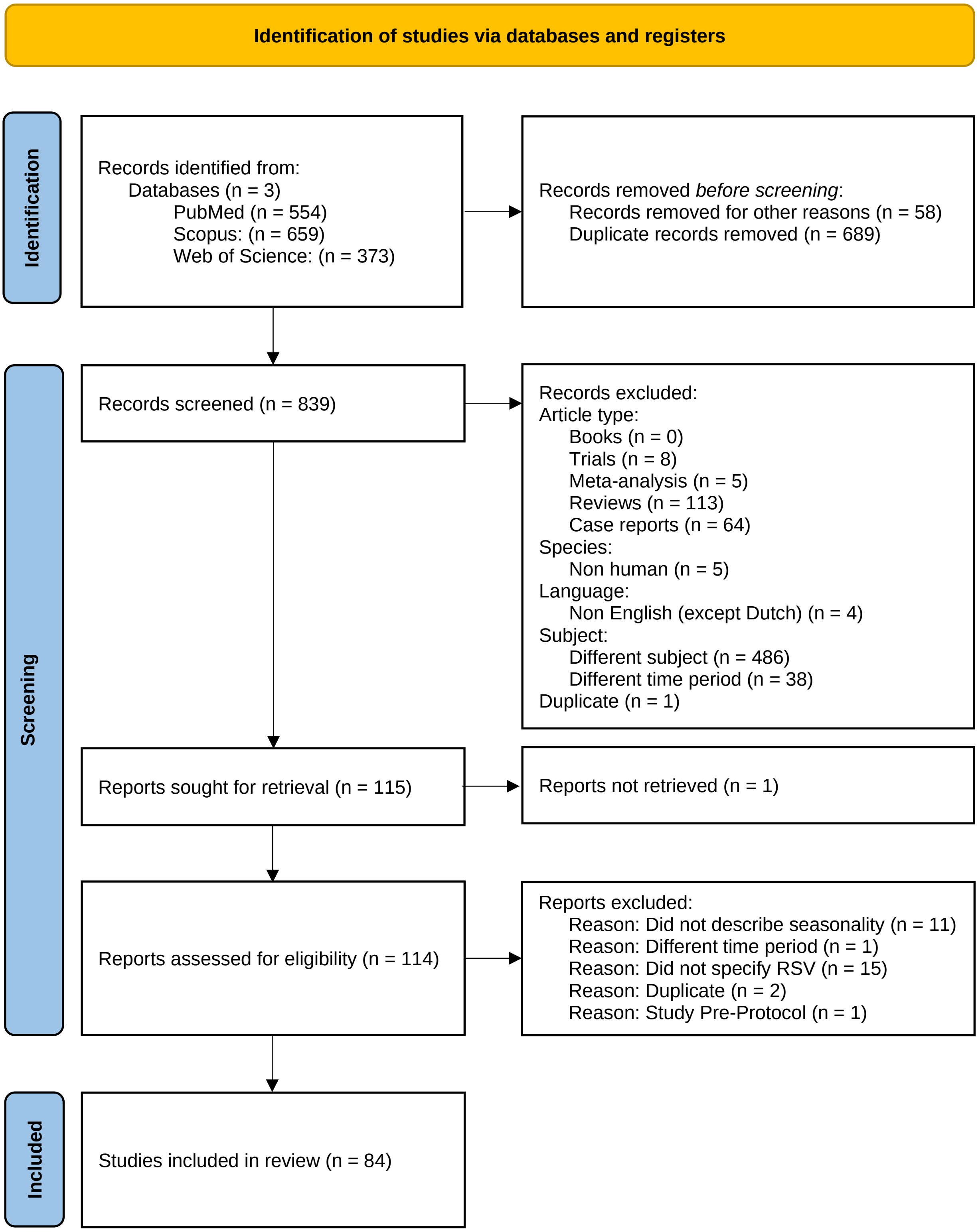
Supplemental table 1. Search Strings and Results

Database	#	Syntax	Results
Pubmed	1	((((Delayed[Title/Abstract]) OR (delay[Title/Abstract])) OR (shift[Title/Abstract])) OR (peak[Title/Abstract])) OR (resurgence[Title/Abstract])	1,090,280
	2	((rsv[Title/Abstract]) OR (Respiratory syncytial virus[Title/Abstract])) OR (Bronchiolitis[Title/Abstract])	28,682
	3	((Non-pharmaceutical interventions[Title/Abstract]) OR (NPI[Title/Abstract])) OR (Nonpharmaceutical interventions[Title/Abstract])	4.646
		1 AND 2 AND 3	10
Pubmed	1	((rsv[Title/Abstract]) OR (Respiratory syncytial virus[Title/Abstract])) OR (Bronchiolitis[Title/Abstract])	28,682
	2	((Non-pharmaceutical interventions[Title/Abstract]) OR (NPI[Title/Abstract])) OR (Nonpharmaceutical interventions[Title/Abstract])	4.646
		1 AND 2	23
Pubmed	1	((rsv[Title/Abstract]) OR (Respiratory syncytial virus[Title/Abstract])) OR (Bronchiolitis[Title/Abstract])	28,682
	2	((((Delayed[Title/Abstract]) OR (delay[Title/Abstract])) OR (shift[Title/Abstract])) OR (peak[Title/Abstract])) OR (resurgence[Title/Abstract])	1,090,280
		1 AND 2 Filters: 2020-2021	190
Pubmed	1	((rsv[Title/Abstract]) OR (Respiratory syncytial virus[Title/Abstract])) OR (Bronchiolitis[Title/Abstract])	28,682
	2	((((((delayed[Title/Abstract]) OR (delay[Title/Abstract])) OR (shift[Title/Abstract])) OR (peak[Title/Abstract])) OR (resurgence[Title/Abstract])) OR (COVID-19[Title/Abstract])) OR (SARS-CoV-2[Title/Abstract])	1,261,246
	3	((Non-pharmaceutical interventions[Title/Abstract]) OR (NPI[Title/Abstract])) OR (Nonpharmaceutical interventions[Title/Abstract])	4.646
		1 AND 2 AND 3	22
Pubmed	1	((rsv[Title/Abstract]) OR (Respiratory syncytial virus[Title/Abstract])) OR (Bronchiolitis[Title/Abstract])	28,682
	2	((((((delayed[Title/Abstract]) OR (delay[Title/Abstract])) OR (shift[Title/Abstract])) OR (peak[Title/Abstract])) OR (resurgence[Title/Abstract])) OR (COVID-19[Title/Abstract])) OR (SARS-CoV-2[Title/Abstract])	1,261,246
		1 AND 2 Filters: 2020-2021	553
Pubmed		**Unique results**	**554**
Scopus	1	TITLE-ABS-KEY (rsv OR "Respiratory syncytial virus" OR bronchiolitis)	46,002
	2	TITLE-ABS-KEY (delayed OR delay OR shift OR peak OR resurgence OR covid-19 OR sars-cov-2)	3,867,150
	3	TITLE-ABS-KEY ("Non-pharmaceutical interventions" OR npi OR "Nonpharmaceutical interventions")	5,830
		1 AND 2 AND 3	20
Scopus	1	TITLE-ABS-KEY (rsv OR "Respiratory syncytial virus" OR bronchiolitis)	3,867,150
	2	TITLE-ABS-KEY ("Non-pharmaceutical interventions" OR npi OR "Nonpharmaceutical interventions")	5,830
		1 AND 2 AND (LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020)) AND (LIMIT-TO (DOCTYPE , "ar"))	18
Scopus	1	TITLE-ABS-KEY (rsv OR "Respiratory syncytial virus" OR bronchiolitis)	3,867,150
	2	TITLE-ABS-KEY (delayed OR delay OR shift OR peak OR resurgence OR covid-19 OR sars-cov-2)	3,867,150
		1 AND 2 AND (LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))	657
Scopus		**Unique results**	**659**
Web of Science	1	AB=(RSV OR "Respiratory syncytial virus" OR Bronchiolitis)	20,607
	2	AB=(Delayed OR Delay OR Shift OR Peak OR Resurgence OR COVID-19 OR SARS-Cov-2)	2,424,886
	3	AB=("Non-pharmaceutical interventions" OR NPI OR "Nonpharmaceutical interventions")	3,895
		1 AND 2 AND 3	13
Web of Science	1	AB=(RSV OR "Respiratory syncytial virus" OR Bronchiolitis)	20,607
	2	AB=("Non-pharmaceutical interventions" OR NPI OR "Nonpharmaceutical interventions")	3,895
		1 AND 2	15
Web of Science	1	AB=(RSV OR "Respiratory syncytial virus" OR Bronchiolitis)	20,607
	2	AB=(Delayed OR Delay OR Shift OR Peak OR Resurgence OR COVID-19 OR SARS-Cov-2)	2,424,886
		1 AND 2 Refined By: Publication Years: 2020 or 2021 Document Types: Articles Languages: English	370
Web of Science		**Unique results**	**373**

Supplemental figure 1. PRISMA Flow Diagram



Adopted from: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

Supplemental table 2. Search results

First Author	Journal	Year of Publication
Rachel E Baker	PNAS	2020
Sonja J Olsen	CDC	2021
Zaid Haddadin	Pediatrics	2021
Michael L Jackson	BMC Infectious Diseases	2021
Rabia Agha	Pediatrics	2021
Xiaoyan Song	Infection Control & Hospital Epidemiology	2021
Parsa Hodjat	Microbiology Spectrum	2021
Loren Rodgers	Clinical Infectious Disease	2021
Elizabeth Partridge	JAMA Network Open	2021
Jeff Nawrocki	Open Forum Infectious Diseases	2021
Leisha D Nolen	Clinical Infectious Disease	2021
Kevin Zhang	Canada Communicable Disease Report	2021
Pascal M Lavoie	Canadian Medical Association Journal	2021
Helen E Groves	The Lancet Regional Health – Americas	2021
Kyu Young Park	PLOS ONE	2021
Pablo Vásquez-Hoyos	Archives of Disease in Childhood	2020
Fernanda Hammes Varela	Journal of Global Health	2021
Sheena G Sullivan	Eurosurveillance	2020
Asmaa El-Heneidy	Australian and New Zealand Journal of Public Health	2021
David Anthony Foley	Archives of Disease in Childhood	2021
David A Foley	Clinical Infectious Diseases	2021
Sarah McNab	Clinical Infectious Diseases	2021
Daniel K Yeoh	Clinical Infectious Diseases	2021
Philip N Britton	The Lancet Child & Adolescent Health	2020
Yara-Natalie Abo	Journal of Paediatric and Child Health	2021
Adrian Trenholme	Emerging Infectious Diseases	2021
Q Sue Huang	Nature Communications	2021
Jong-Hun Kim	International Journal of Infectious Diseases	2021
Sangshin Park	The Journal of Infectious Diseases	2021
Qi Yang	International Journal of Infectious Diseases	2021
Pengcheng Liu	Virology Journal	2021
Yueling Zhu	BMC Pediatrics	2021
Jinhui Wang	Frontiers in Pediatrics	2021
Shuk-Ching Wong	Infectious Control and Hospital Epidemiology	2021
Li Li	Virology Journal	2021
Ruo-Xi Zhang	World Journal of Pediatrics	2021
Fei Li	Infectious Disease and Therapy	2021
Xinke Du	Archives of Virology	2021
Chuang-Xing Lin	Epidemiology and Infection	2021
Keita Wagatsuma	BMC Infectious Diseases	2021
Lina Madaniyazi	Japanese Journal of Infectious Disease	2021
Mugen Ujiie	Emerging Infectious Diseases	2021
Takuma Ohnishi	Journal of the Pediatric Infectious Diseases Society	2021
Emi Takashita	Influenza and other Repiratory Viruses	2021
Yuya Fukuda	Journal of Infection and Chemotheraoy	2021
Yuji Maruo	Pediatric International	2021
Koichi Shichijo	PLOS ONE	2021
Yumi Kang	Pediatric International	2021
Sachiko Yamamoto Kataoka	Pediatric International	2021
Ilada Thongpan	Influenza and other Repiratory Viruses	2021
Thomas C Williams	Eurosurveillance	2021
Jojanneke van Summeren	Eurosurveillance	2021
Juan Manuel Rius-Peris	Anales de Pediatría (English Edition)	2021
Patricia Flores-Pérez	Enfermedades Infecciosas y Microbiología Clínica (English Edition)	2021
Daan Van Brusselen	European Journal of Pediatrics	2021
Jean-Sebastien Casalegno	Eurosurveillance	2021
Jacques Fourgeaud	European Journal of Clinical Microbiology & Infectious Diseases	2021
Alexis Rybak	The Pediatric Infectious Disease Journal	2021
Céline Delestrain	Pediatric Pulmonology	2021
Jean-Michel Mansuy	Journal of Medical Virology	2021
Ilari Kuitunen	Infectious Diseases	2021
Ilari Kuitunen	The Pediatric Infectious Disease Journal	2021
Marjut Haapanen	EClinicalMedicine	2021
Sergio Ghirardo	Pediatric Pulmonology	2021
Adriana Calderaro	International Journal of Infectious Diseases	2021
Anna Chiara Vittucci	International Journal of Environmental Research and Public Health	2021
Maria Antonia De Francesco	International Journal of Environmental Research and Public Health	2021
Giulio Ippolito	Frontiers in Pediatrics	2021
Cristina Galli	Viruses	2021
Francesco Maria Risso	Acta Paediatrica	2021
Toby A Eyre	British Journal of Haemtology	2021
Elisabeth Mahase	BMJ	2021
Alix L von Hammerstein	Swiss Medical Weekly	2021
Paul Stamm	Medical Microbiology and Immunology	2021
Matthias Lange	Deutsches Ärzteblatt International	2021
Monika Redlberger-Fritz	Journal of Clinical Virology	2021
Stefano Tempia	Eurosurveillance	2021
Ivan Sanz-Muñoz	Vaccines	2021
Valentina Coutinho Baldoto Gava Chakr	Postgraduate Medical Journal	2021
Talha Khan Burki	The Lancet Respiratory Medicine	2021
Eric Farfour	Journal of Clinical Virology	2021
Emma Binns	Pediatric Pulmonology	2021
Moran Weinberger Opek	Eurosurveillance	2021
Harun Agca	Journal of Infection and Public Health	2021