

# Weather and its effects on RSV A and B infections in infants and children in Korea

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## RESEARCH

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## ABSTRACT

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### Background

The epidemic patterns of respiratory syncytial virus (RSV) infection and the factors determining its seasonality are not well studied in the local society of South Korea.

### Aims

This study aims to investigate the prevalence of RSV infection in hospitalized children and its relationship with climate change in Cheonan, Korea.

### Methods

This retrospective study included 2,484 children (aged 0–14 years) who were hospitalized for respiratory tract infections documented RSV test at a tertiary hospital in Cheonan between December 2006 and February 2014. Daily temperature and humidity data during the period were obtained from the Korea Meteorological Administration.

### Results

In total, 752 (30 per cent) showed tested positive for RSV

infection, and the prevalence was noted to be higher during November and December. RSV A and RSV B were less likely to be detected simultaneously (0.4 per cent). RSV A was more likely to be detected during lower temperatures, lower wind speeds, and shorter daylight hours, and RSV B during lower daily precipitation and higher humidity. RSV infection was predominantly prevalent between November and April. The infection rate of RSV peaked every other year in Korea. Air temperature was associated with the epidemics of RSV infection.

### Conclusion

Further understanding of the effect of climate on RSV infection will help in timely prevention using immunoprophylaxis or future vaccines.

### Key Words

Climate, meteorology, respiratory syncytial virus

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### What this study adds:

#### 1. What is known about this subject?

RSV infection can present with common cold symptoms. However, epidemiological studies of the infection route have not been conducted.

#### 2. What new information is offered in this study?

RSV A was more likely to be detected at lower temperatures, wind speeds, and shorter daylight hours, and RSV B during daily precipitation and higher humidity.

#### 3. What are the implications for research, policy, or practice?

Considering the meteorological variables, we can identify the pattern of infection for RSV and provide proactive preventive guidelines for infection.

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### Background

Respiratory syncytial virus (RSV) is a leading cause of acute

respiratory tract infections in infants and younger children.<sup>1</sup> It may progress to severe pneumonia and death.<sup>2</sup> The mortality rate associated with RSV bronchiolitis is nine times that of influenza virus during the first year of life.<sup>3</sup> Compared with adults, infants are increased risk of complications partly related to immaturity of their immune system.<sup>4</sup> And they are inherently sensitive to changes in weather because they are physiologically and metabolically less effective at adapting to ambient humidity and other weather-related exposures.<sup>5</sup>

In recent years, it has been increasingly recognized that ambient temperature has a significant impact on the prevalence of paediatric respiratory illnesses.<sup>6</sup> Lower temperature, lower ultraviolet (UV) B radiation, and higher humidity prolong the survival of respiratory viruses in the environment.<sup>7</sup> In temperate countries, seasonal variation of activity of respiratory viruses has been reported, particularly in association with temperature.<sup>8</sup> RSV have been reported to peak during winter in both of the northern and southern hemispheres.<sup>9</sup> RSV activity tends to rise in the coldest months in temperate regions, where winter outbreaks are common, and in the warmest months in subtropical climates.<sup>10</sup>

Identifying geographical and seasonal distribution, weather conditions, and avoiding infection plays an important role in preventing the spread of infection.<sup>11</sup> Therefore, we studied the pattern of RSV infections and its relationship to meteorological variations in the local city of Cheonan from 2006–2014, especially in infants less than one year of age and analysed the effect of each meteorological variable on RSV infection.

## Method

The present study was approved by the institutional review board (IRB) of Dankook University (Date of IRB approval: 2015.10.13; IRB approval No.: 2015-09-009).

### Data collection

Cheonan, South Korea, comprises of two districts encompassing an area of 636.3km<sup>2</sup> and had a population of 700,000 in 2015. It is situated at a latitude of 36°48' N and demonstrates a typical subtropical climate with an average annual temperature of 11.8°C. Weather data, such as mean temperature, dew point, relative humidity, precipitation, and pressure were obtained from the Korea Meteorological Administration that used the Automatic Weather Observation System to record them between December 2006 and February 2014 in Cheonan area. A total of 6,279 patients under one years of age who were treated at

Dankook University Hospital for respiratory symptoms in the same period were included in the study. Nasopharyngeal aspirate samples for RSV PCR were collected using a mucus extractor and samples were stored at 4°C until nucleic acid extraction was performed.

### Statistical analysis

Statistical program R was used to examine the relationship between meteorological factors and RSV variables. Frequency analysis was performed for individual characteristics; in this study, cross-analysis ( $\chi^2$ , chi-squared) was performed to determine the relationship of weather parameters and RSV A and B, with the latter as dependent variables. Variation index factor and tolerance were used to prevent confounding factors in the regression coefficient by increasing the variance of the regression coefficient. In the study, the problem of the multicollinearity was solved using correlation coefficient. Logistic regression analysis was performed to examine the meteorological factors influencing RSV A and B infection. For each dependent variable, we assigned a value of 1 for infection and a value of 0 for no infection.

## Results

### Analysis of patients

A total of 6,279 patients were tested for RSV PCR during the study period. Of these, 2,484 were infants aged less than one year and 1,087 were less than 100 days old. The younger the age group, the greater was the number of patients. Of the total study population, 2,025 patients tested positive for infection with a single RSV (Table 1). And 752 patients were infected with RSV A, 500 patients with RSV B, and 10 patients with RSV A and B (Table 2).

RSV A and B were found to occur during October to January, and more frequently during November to December (Figure 1).

A total of 1,242 patients (50.0 per cent) were not infected with the virus, and only 10 patients (0.4 per cent) were infected with, both, RSV A and B (Table 2). Therefore, patients were less likely to be infected with RSV A and B simultaneously, which was statistically significant ( $\chi^2=237.07$ ,  $p<0.001$ ).

### Analysis of personal and meteorological characteristics

In the case of RSV A, there was a significant relationship between individual characteristics, except the sex of the patient. The lower the age, the higher was the likelihood of infection with it. There was a higher rate of infection with

lower average temperature, lower average wind speed, and shorter sunshine duration in day (Table 3).

In the case of RSV B also, the lower the age, the greater was the possibility of infection. The rates of infection were higher with lower daily precipitation, higher humidity, and stronger wind speed. The statistical significance was relatively low (Table 3).

## Discussion

In temperate climates, RSV activity was found to be maximal during winter.<sup>9,12</sup> During a 10-year study period, RSV infection was found to be prevalent in December, peaking in February, subsiding in March, April, and May, and, finally, disappearing during the summer months.<sup>11</sup> These results suggest that RSV activity is related to temperature.<sup>13-15</sup> and suggest that RSV activity is related to temperature. In this study, the peak RSV activity occurred from mid-October to early January. For a majority of the study period, no cases were identified between April and late September. RSV activity was also increased when the mean relative humidity was between 45–65 per cent.

The stability of RSV in aerosols is dependent on humidity.<sup>11</sup> The maximum and minimum stability of the RSV, in large particle aerosols, for one minute were 90 per cent and less than 20 per cent humidity, respectively. In case of small particle aerosols, RSV could maintain the stable status up to 60 min at 40 per cent humidity.<sup>16</sup> In our study, statistically significant negative correlation was found between RSV and UV radiation. These results indicating that the frequency of RSV infection was in inverse proportion to the UV radiation. UV-B was found to have a much greater effect on survival of RSV on surfaces in the environment, and, thus, had effects on transmission via contact with fomites.<sup>17,18</sup> Previous studies have shown that the relationship between temperature, relative humidity, and frequency of occurrence can be a cause of influenza seasonality.<sup>19-21</sup> The amplitude and timing of seasonality in the transmission rate was significantly correlated with seasonal fluctuations in potential evapotranspiration, and negatively correlated with mean vapour pressure, minimum temperature, and precipitation.<sup>10</sup>

Our study has several limitations. First and the most important, is the variation between indoor climatic conditions and those of outdoor environments. Second, the results are limited to the Cheonan area. Third, because the study only included infants and toddlers, the results may be different from that of the whole population. Further studies are required for ascertaining these findings. However, the area has four distinct seasons because of the temperate

climate. Therefore, the climate changes were clear and it was easy to observe the pattern of infection with these viruses than it would be in other areas. The findings of this study are significant because until now, RSV A and RSV B, together, have not been reported in many cases.

## Conclusion

The statistical results of this study showed that the weather conditions in the winter included sunlight's UV radiation, temperature, wind speeds and humidity could increase the inactivation of influenza virus in the environment, and consequently the infection rate of RSV A and B were increased in the children population in the Cheonan, Korea. Therefore, maintaining indoor humidity at 30–40 per cent and disinfection with UV can be useful in reducing the survival of RSV within these areas. Further analyses of the environmental variables will be useful in determining the vaccination timing, patient treatment and infection prevention in the future.

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#### PEER REVIEW

Not commissioned. Externally peer reviewed.

#### CONFLICTS OF INTEREST

The authors have no conflict of interest to declare.

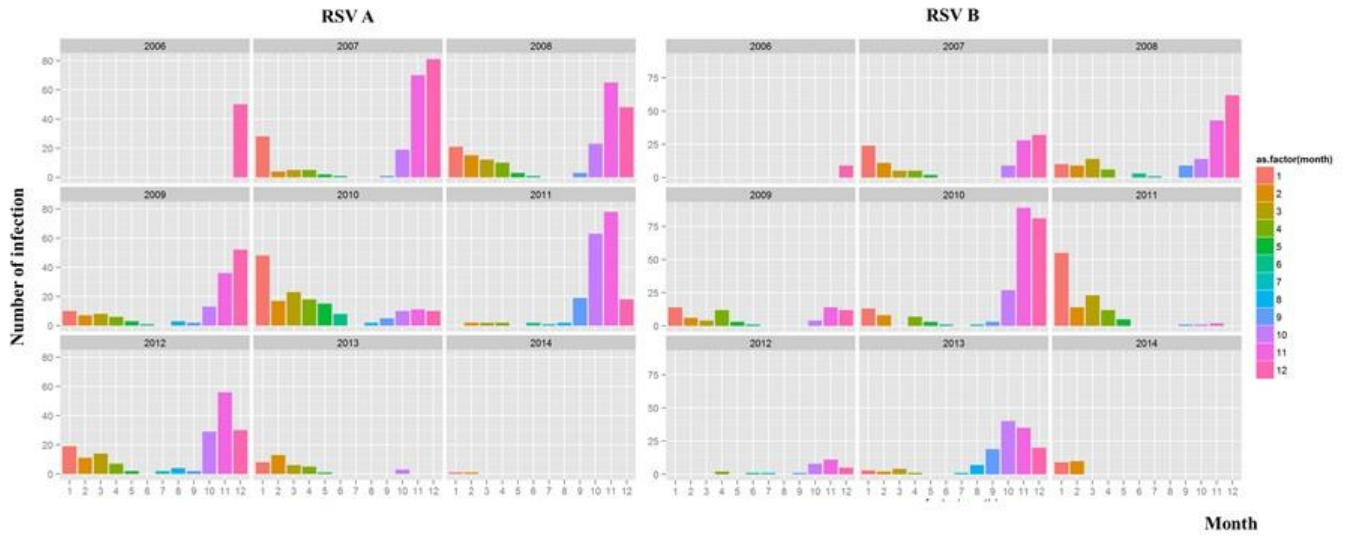
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#### ETHICS COMMITTEE APPROVAL

The present study was approved by the institutional review board (IRB) of Dankook University (Date of IRB approval: 2015.10.13; IRB approval No.: 2015-09-009).

**Figure 1: Distribution of monthly infection by year**



**Table 1: Characteristics of patients who visited Dankook University hospital**

Parameter	Subscripts	Specimens	(%)
Sex	Male	1499	(60.3)
	Female	985	(39.7)
Age	Under 100 days	1087	(43.8)
	100– 200 days	650	(26.2)
	200– 300 days	483	(19.4)
	Over 300 days	264	(10.6)
Multiple infection	Single	2025	(81.5)
	Double	416	(16.7)
	Triple	43	(1.8)
Infected virus	RSV A infection	752	(30.3)
	RSV B infection	500	(20.1)
	RSV A and B infection	10	(0.4)
	Total	2484	(100)

**Table 2: Cross-analysis of RSV A and RSV B**

Specimens (%)		RSV B				Total		x <sup>2</sup>
		Positive		Negative				
RSV A	Positive	10	(0.4)	742	(29.9)	752	(30.3)	237.07*
	Negative	490	(19.7)	1242	(50)	1732	(69.7)	
Total		500	(20.1)	1984	(79.9)	2484	(100)	

\*P<0.001

**Table 3: Regression analysis results of statistically significant various variables**

Variable	Association with			
	RSV A		RSV B	
	Estimate standard	<i>p value</i>	Estimate standard	<i>p value</i>
Sex (male=1, female=0)	0.084	0.372	-0.019	0.862
Age	-0.003	0.017	-0.002	0.009
Average temperate	-0.056	<0.001	-0.069	<0.001
Daily precipitation	-0.013	0.089	-0.045	0.003
Average wind speed	-0.263	<0.001	0.161	0.01
Average humidity	0.001	0.859	0.027	<0.001
Sunshine duration in day	-0.059	<0.001	0.017	0.356