Atmospheric Relative Humidity Can Increase the Spread of COVID-19

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Abstract

COVID-19 has been spreading around the world since the end of 2019, and there is no sign of a slowdown. Previous studies on seasonality of similar infectious diseases have hinted that meteorological factors may influence COVID-19 outbreaks as well¹. Here we show, based on data collected in 132 cities of China, that relative humidity, as an essential meteorological indicator, is positively correlated with the growth rate of incidence of COVID-19, which contradicts previous research findings. Our result suggests an increasing risk of COVID-19 cases as summer and rain seasons arrive in many places of the world. They also help countries and regions to formulate pandemic prevention and control measures and policies according to local meteorological characteristics.

Main Text

COVID-19 is an ongoing infectious disease caused by a novel coronavirus named SARS-CoV-2¹⁻⁵. The outbreak was officially declared a pandemic by WHO on March 11th, 2020. Today, it has inflicted more than 7 million people and caused more than 400,000 deaths worldwide. Studies have shown that various public health measures, including handwashing, face masking, social distancing, and restricting the movement, have contributed significantly to control the spread⁶⁻⁹. However, with no effective treatments available and vaccines still months away, scientists around the world are racing to develop models that can predict if and when the second wave will come. Given the evidence that there are mitigating effects of warmer temperatures, humidity and sunlight on other infectious diseases such as pneumonia and flu, there have been speculations that weather factors may play a similar role on COVID-19^{1,10}. Here we analyzed the early outbreak data in China and its correlation with meteorological factors. Our results provide evidence that atmospheric humidity facilitates rather than hinders the infection, contrary to a common belief that warm and humid weather can slow down the spread of the virus^{1, 2}.

Previous studies on the relationship between atmospheric humidity and COVID-19 pandemic have shown that the higher the humidity is, the more favorable it is to control the pandemic^{2,11}. However, these conclusions are contrary to the previous findings of the relationship between atmospheric humidity, pneumonia, and influenza¹²⁻¹⁴. We believe that there are many methodological problems in previous studies on the relationship between

atmospheric humidity and COVID-19 pandemic, which may lead to unreliable conclusions. First, some studies only observed data for three days², which is not enough to reflect the relationship between atmospheric humidity and the long-term development of the pandemic (overall incidence rate). Second, most of the studies used meteorological data at the provincial or even national level^{11,15}, which is not reasonable, because the regional meteorological differences within a province or country are often large, while the average meteorological characteristics of two neighboring provinces or countries may be very close. This method may cover up the real relationship between atmospheric humidity and COVID-19 pandemic. Third, previous studies used the number of new cases per day in a period of time that was arbitrarily chosen^{2,11}, without taking into account the number of initial cases and the highest number of cases in a region, and therefore could not objectively reflect the largest incidence rate in the region. Fourth, some studies included data after outbreaks began to decline¹⁶, which may confuse atmospheric factors with human management measures and therapeutic effects. The methods adopted in this study overcome the above problems.

We collected data from 132 Chinese cities to test the impact of natural climate factors on the pandemic's growth rate (see Method for details). We selected the pandemic data (the number of increased cases per day) of each city in the fastest-growing regions of the pandemic since January 23rd (the day of closure of Wuhan) to March (when the confirmed COVID-19 cases of all cities first reached the peak). Besides, we collected the average daily atmospheric temperature, average relative humidity, and average air pressure of the 132 cities during the period. We also collected the GDP data (2019), population density data (2018) and the distance to Wuhan of each city.

We used general linear regression for the analysis. First, we took GDP, population density, distance, temperature, temperature range and air pressure as independent variables, and the pandemic growth rate as the dependent variable for analysis (see Formula 1). The results showed that the distance negatively related to the growth rate of

the pandemic ($B=-0.34$, $p=0.001$). Temperature had a marginally significant correlation with the growth rate of the pandemic ($B=-0.21$, $p=0.07$). Second, we took GDP, population density, distance, temperature, temperature range, atmospheric pressure, and atmospheric relative humidity as independent variables and the pandemic growth rate as the dependent variable for analysis (see Formula 2). The results showed that atmospheric relative humidity significantly predicted the growth rate of the pandemic ($B=0.40$, $p=0.001$) (see Table 1), and the higher the relative humidity in cities, the higher the local incidence (see Figure 1). Temperature was negatively associated with the growth rate of the pandemic ($B=-0.26$, $p=0.02$). The distance was negatively correlated to the pandemic growth rate ($B=-0.32$, $p=0.001$).

$$R_{\text{growth}} = \beta_1 GDP + \beta_2 PD + \beta_3 Tem + \beta_4 RTem + \beta_5 Air + \beta_6 Dis + \alpha_1 \quad (1)$$

$$R_{\text{growth}} = \beta_7 GDP + \beta_8 PD + \beta_9 Tem + \beta_{10} RTem + \beta_{11} Air + \beta_{12} Dis + \beta_{13} ReHum + \alpha_2 \quad (2)$$

Note: G=Growth Rate, PD=Population density, Tem=Temperature, RTem=Temperature Range, Air= Air Pressure, Dis=Distance, ReHum=Relative humidity. β =Regression coefficient, α =Residual.

Table 1 The Regression Model of Growth Rate on Atmospheric Environment

Variables	DV= Growth Rate		DV= Growth Rate	
	<i>B</i>	<i>P</i>	<i>B</i>	<i>P</i>
GDP	-0.04	0.77	-0.03	0.81
Population density	0.10	0.45	0.10	0.39
Distance	-0.34**	0.001	-0.32**	0.001
Temperature	-0.21	0.07	-0.26*	0.02
Temperature Range	-0.07	0.50	0.08	0.47
Air Pressure	0.15	0.10	-0.01	0.93
Relative humidity			0.40***	0.000
<i>R</i> ²	0.15		0.23	
ΔR^2			0.08	

Note: $N=132$. * $p \leq 0.05$ *** $p \leq 0.001$.

The transmission rate of the pandemic will be influenced by natural climatic factors as well as humanistic and social factors¹⁷. The current study found a significant positive correlation between atmospheric relative humidity and the increase of pandemic situation, indicating that the virus may survive longer in the environment with high relative humidity. The findings put forward a warning to the pandemic prevention and control in special cities and regions: cities with high relative humidity are more likely to spread the COVID-19 pandemic, and special precautions should be taken.

It should be noted that this study found that relative humidity positively predicted the transmission of COVID-19, which is inconsistent with previous studies^{2,11}. The reason may be that the previous study only selected three days of data, making its conclusion very limited. The period of relative humidity data selected in this study is much more extended, so our conclusion should be universal.

Our findings provide new insights into the relationship between climate and the COVID-19 pandemic. In particular, with the coming of summer in the northern hemisphere, the atmospheric relative humidity in many cities will further increase, which may aggravate the spread of COVID-19. All urban administrative departments and medical institutions shall take corresponding prevention and control measures in advance.

Method

To investigate the effect of climate on the pandemic, we collected COVID-19 pandemic data from 132 Chinese cities for analysis. The principle of selecting cities is to include all municipalities directly under the central government and the top five cities in each province in terms of confirmed cases. If there are less than five cities in the province with the COVID-19 pandemic, all of these cities with confirmed cases were selected (for example, only two cities in Qinghai province have confirmed COVID-19 cases, so data from both cities are used for analysis). The epidemic data were collected from the National Health Commission of China⁷, Sina News¹⁹, and Git-Hub¹⁸.

Since the spreading of the pandemic may be affected by population mobility, we choose the date of Wuhan city closure (January 23th) as the starting point of our data collection to control the population mobility. As long-distance may weaken the spreading of the pandemic, we also controlled for the distance from each city to Wuhan. To better reflect the pandemic's spreading tendency, we use the date when the number of confirmed cases in the city reached the highest point for the first time as the endpoint of data collection in this city to calculate the epidemic growth rate of the city. The formula is as follows:

$$R_{\text{growth}} = \text{Log} [(E-S)/(S \times T)]$$

Note R_{growth} = Growth rate, E= Ending value of confirmed cases, S= Starting value of confirmed cases, T= Time period.

The reason why we choose the maximum growth rate instead of the number of cases per day as the dependent variable is that the maximum growth rate can best reflect the spread trend of the epidemic, while the number of cases per day can not well reflect the change tendency of the pandemic.

The atmospheric data were obtained from the official website of China Meteorological Administration ²⁰. We collected the data of mean temperature, the range of temperature, mean relative humidity, and air pressure of each city. Since urban GDP and population density may affect the spread of the pandemic, we obtained the latest data from the National Bureau of Statistics of China²¹ and controlled for urban GDP(2019) and population density(2018) in the following analysis.

Statements

All data were from public open database. We confirm that all methods were carried out in accordance with relevant guidelines and regulations. This manuscript did not involve in any experiments on humans and/or the use of human tissue samples. The study protocol was approved by the Ethics Commission of School of Psychological and Cognitive Sciences at Peking University.

References

1. Will Warm Weather Slow Spread of Novel Coronavirus?
<https://directorsblog.nih.gov/2020/06/02/will-warm-weather-slow-spread-of-novel-coronavirus/>.
2. Wang, J., Tang, K., Feng, K., Lin, X., Lv, W., Chen, K. & Wang, F. High temperature and high relative humidity reduce the transmission of COVID-19 (March 9th, 2020). Available at SSRN:
<https://ssrn.com/abstract=3551767> or <http://dx.doi.org/10.2139/ssrn.3551767>.
3. Poh, C. M., Carissimo, G., Wang, B., Amrun, S. N., Lee, C. Y., Chee, R. S., . . . Ng, L. F. P. Two linear epitopes on the SARS-CoV-2 spike protein that elicit neutralising antibodies in COVID-19 patients. *Nature Communications*. 11, 1-7(2020).
4. Zhou, P. et al. A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature*. 579. 270-273 (2020).
5. World Health Organization (WHO), Novel Coronavirus China (WHO, 2020); www.who.int/csr/don/12-january-2020-novel-coronavirus-china/en/.
6. Chinazzi, M., Davis, J.T., Ajelli, M., Gioannini, C., Litvinova, M., Merler, S., et al. The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. *Science*. 368, 395–400 (2020).
7. Chinese Center for Disease Control and Prevention. <http://www.chinacdc.cn/jkzt/>.
8. Maier, B. F. & Brockmann, D. Effective containment explains subexponential growth in recent confirmed COVID-19 cases in China. *Science*. 368, 742-746(2020).
9. WHO, Report of the WHO-China joint mission on coronavirus disease 2019 (COVID-19) (2020).
10. Temperature significant change COVID-19 transmission in 429 cities (published February 25th, 2020) (2020). NewsRX LLC.
11. Wu, Y., Jing, W., Liu, J., Ma, Q., Yuan, J., Wang, Y., . . . Liu, M.. Effects of temperature and relative humidity on the daily new cases and new deaths of COVID-19 in 166 countries. *The Science of the Total Environment*. 729, 139051(2020).
12. Casanova, L. M., Jeon, S., Rutala, W. A., Weber, D. J., & Sobsey, M. D. Effects of air temperature and relative relative humidity on coronavirus survival on surfaces. *Applied and Environmental Microbiology*. 76, 2712-2717 (2010).
13. China Meteorological Administration
http://www.cma.gov.cn/kppd/2011qqxkp/2011qkpd/201212/t20121213_196076.html.
14. Lam, E. K. S., Morris, D. H., Hurt, A. C., Barr, I. G., & Russell, C. A. The impact of climate and antigenic evolution on seasonal influenza virus epidemics in australia. *Nature Communications*. 11, 1-12(2020).
15. Gupta, S., Raghuwanshi, G. S., & Chanda, A. Effect of weather on COVID-19 spread in the US: A prediction model for india in 2020. *Science of the Total Environment*. 728, 138860 (2020).
16. Liu, J., Zhou, J., Yao, J., Zhang, X., Li, L., Xu, X., . . . Zhang, K. Impact of meteorological factors on the COVID-19 transmission: A multi-city study in china. *The Science of the Total Environment*. 726, 138513(2020).

17. Lam, E. K. S., Morris, D. H., Hurt, A. C., Barr, I. G., & Russell, C. A. (2020). The impact of climate and antigenic evolution on seasonal influenza virus epidemics in australia. *Nature Communications*. 11(1), 1-12.
18. GitHub Novel-Coronavirus-Updates. <https://github.com/839Studio/Novel-Coronavirus-Updates>.
19. https://news.sina.cn/zt_d/yiqing0121?vt=4&pos=undefined&utm_source=wechat_session&utm_medium=social&utm_oi=38764470599680
20. China Meteorological Administration. <http://www.cma.gov.cn/>.
21. National Bureau of Statistics. <http://www.stats.gov.cn/>.

Declaration

Competing interests: The authors declare no competing interests.

Figures

b

Figure 1

1a The effect of relative humidity and the growth rate of COVID-19 | The horizontal axis represents the average air relative humidity of each city in the last three months (90 days). The vertical axis represents the growth rate of COVID-19; it means an average multiple of the initial value per day. 1b The relationship between relative humidity and the growth rate of COVID-19 | The color of the histogram represents the atmospheric relative humidity of each city, and the volume of the histogram represents the growth rate of

the COVID-19. The deeper the histogram, the higher humid in the atmosphere. The larger the histogram, the faster the growth rate. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.