



Review

Weather Variability and COVID-19 Transmission: A Review of Recent Research

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Abstract: Weather and climate play a significant role in infectious disease transmission, through changes to transmission dynamics, host susceptibility and virus survival in the environment. Exploring the association of weather variables and COVID-19 transmission is vital in understanding the potential for seasonality and future outbreaks and developing early warning systems. Previous research examined the effects of weather on COVID-19, but the findings appeared inconsistent. This review aims to summarize the currently available literature on the association between weather and COVID-19 incidence and provide possible suggestions for developing weather-based early warning system for COVID-19 transmission. Studies eligible for inclusion used ecological methods to evaluate associations between weather (i.e., temperature, humidity, wind speed and rainfall) and COVID-19 transmission. The review showed that temperature was reported as significant in the greatest number of studies, with COVID-19 incidence increasing as temperature decreased and the highest incidence reported in the temperature range of 0–17 °C. Humidity was also significantly associated with COVID-19 incidence, though the reported results were mixed, with studies reporting positive and negative correlation. A significant interaction between humidity and temperature was also reported. Wind speed and rainfall results were not consistent across studies. Weather variables including temperature and humidity can contribute to increased transmission of COVID-19, particularly in winter conditions through increased host susceptibility and viability of the virus. While there is less indication of an association with wind speed and rainfall, these may contribute to behavioral changes that decrease exposure and risk of infection. Understanding the implications of associations with weather variables and seasonal variations for monitoring and control of future outbreaks is essential for early warning systems.

Keywords: COVID-19; weather; temperature; humidity; precipitation; wind speed; seasonality



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1. Introduction

In December 2019, the World Health Organization (WHO) was alerted to cases of atypical pneumonia with unknown etiology in the city of Wuhan, Hubei Province, China. The disease, termed COVID-19 (Coronavirus Disease 2019) spread by human-to-human transmission from China throughout Asia and into Europe, North America, South America and Oceania and declared a pandemic by the WHO on 11 March 2020 [1,2]. As of 16 December 2020, over 74.7 million cases have been confirmed in 214 countries and territories, with over 1.65 million deaths recorded as a result of COVID-19 [3]. The three most affected countries account for 45.7% of all cases globally and include the US, with 23% of all cases ($n = 17,163,944$), India with 13.3% of cases ($n = 9,956,557$) and Brazil with 9.4% of all cases ($n = 7,040,608$) and 38.5% of total global deaths from the US (18.7% $n = 310,095$), Brazil (11.1% $n = 183,735$) and India (8.7% $n = 144,451$) (Figure 1).

average absolute humidity ($r = 0.59$) were reported as having a stronger significant positive correlation with COVID-19 cases compared with relative humidity ($p < 0.01$) [50].

3.3.3. Wind Speed

Wind speed was included or mentioned in ten studies (43.5%). Wu et al., Xie and Zhu and To et al. included wind speed in the model as a confounder and no results were reported [31,34,37]. Of the remaining seven studies, including wind speed as a weather variable, three reported significant associations between wind speed and COVID-19 cases. Adekunle et al. reported a significant positive association with wind speed, where a 1% increase in average wind speed was associated with 11.21% (95% CI: 0.51–1.19) increase in COVID-19 cases in countries in Africa [43]. Pani et al. reported a significant negative correlation with wind speed and COVID-19, where an increase in wind speed is associated with decreased incidence of COVID-19 ($r = -0.6$, $p < 0.001$) [50]. Alkhowailed et al. also reported a significant negative correlation with maximum and average wind speed ($p < 0.001$ and $p < 0.01$, respectively) [44]. Bashir et al., Bukhari et al., Menebo, and Zhu et al. did not report a significant association between wind speed and daily cases of COVID-19 [29,33,40,51].

3.3.4. Precipitation

Precipitation or rainfall was included in six studies (26.1%, $n = 6/23$), no significant correlation was reported for rainfall or precipitation and COVID-19 in studies from New York, USA; Jakarta, Indonesia or NSW, Australia [33,42,49]. To et al. included rainfall as a control variable, no results reported. Chien and Chen reported a significant negative correlation between rainfall and COVID-19 incidence in the US, with daily cases increasing between 1.27–1.74 inches of rainfall and decreasing with rainfall over 1.77 inches of rainfall (<0.0001) [35]. Menebo also reported a significant negative correlation, with daily precipitation levels recorded at 7 a.m. in Oslo, Norway ($p < 0.05$) [51].

4. Discussion

The relationship between weather variables and COVID-19 transmission is complex. Exploring association and correlation with weather variables and COVID-19 transmission dynamics is complicated when considering the global scale of a pandemic and additional factors involved in the COVID-19 pandemic including healthcare interventions; public health measures; human behavioral patterns and socio-economic factors. The majority of studies analyzed in this review reported significant associations between weather variables and COVID-19 cases, particularly temperature and humidity, suggesting that weather and climate play a role in transmission dynamics. The overall effect of this association varies, so while seasonal variations and weather patterns may contribute to the increased transmission of COVID-19, other factors such as human behavior and public health measures may play a more significant role in future outbreaks.

4.1. Weather Variables and COVID-19

The findings of this review suggest that there is a significant association between both temperature and humidity and COVID-19 incidence, while there is limited evidence for an association between wind speed and precipitation and COVID-19 cases. The significant effect of temperature and humidity on COVID-19 incidence is consistent with findings in earlier studies on airborne respiratory viruses, including SARs, influenza, respiratory syncytial virus (RSV) and MERs [18,52,53].

The studies assessed in this review suggest that ambient or environmental temperature is the most consistently significant weather variable associated with COVID-19 incidence, 90% of the assessed studies reported a strongly significant or significant association with new daily cases of COVID-19, with one study reporting daily cases decreased by 13.53% (95% CI: 1.53–4.63) with a 1 °C increase in mean daily temperature [43]. There was some difference in the range of temperatures between studies reporting negative versus positive