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Early View

Research letter

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No Association of COVID-19 transmission with temperature or UV radiation in Chinese cities

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Backgrounds

The Coronavirus (COVID-19) epidemic, which was first reported in December 2019 in Wuhan, China, has caused 80,904 confirmed cases as of 9 March 2020, with 28,673 cases being reported outside of China. It has been declared a pandemic by the World Health Organization which exhibited human-to-human transmissibility and spread rapidly across countries[1]. Although Chinese government has taken various measures to control city-to-city transmission (*e.g.* shutting down cities, extending holidays) and many countries have implemented measures such as airport screening and testing of patients who have reported symptoms, the number of cases still increases quickly throughout the world.

Previous studies have shown the importance of weather variables in the transmission of infectious diseases, including, but not limited to, influenza and severe acute respiratory syndrome (SARS). For example, a sharp change of ambient temperature was associated with increased risk of SARS[2, 3]. Also, influenza transmission is often enhanced in the presence of cold and/or dry air[4]. In northern Europe, low temperature and low UV Indexes were correlated with peaks of influenza virus activity during 2010-2018[5]. Therefore, it is hypothesized that COVID-19 transmission may decrease or even disappear when the temperature and UV radiation increase in the summer. In this study, we aim to determine the association of meteorological factors with transmission of COVID-19 in various Chinese cities.

Methods

We collected COVID-19 confirmed case information in China reported by the National Health Commission (http://www.nhc.gov.cn/xcs/xxgzbd/gzbd_index.shtml) and the Provincial Health Commissions of China (http://wjw.hubei.gov.cn/bmdt/ztzl/fkxxgzbdgrfyyq/). We used the cumulative number of confirmed cases from 224 cities (207 outside Hubei, 17 inside Hubei) with no less than 10 cases as of Mar 9, and calculated basic reproduction number (R_0) for 62 cities (50 outside Hubei, 12 inside Hubei) with more than 50 cases as of February 10 (COVID-19 peak time in China). R_0 means the expected number of secondary cases generated by an initial infectious individual, in a completely susceptible population. If $R_0 < 1$, then the disease free equilibrium is locally asymptotically stable; whereas if $R_0 > 1$, then it is unstable. Thus, R_0 is a threshold parameter.

Meteorological data, including daily mean temperature and relative humidity, were collected from the China Meteorological Data Sharing Service System. Regarding the UV radiation, daily erythemally weighted daily dose (EDD) data were extracted from the Dutch-Finnish Ozone Monitoring Instrument (OMI) Level 2 UV irradiance products with version 003 (OMUVB V003) at 13km x 24km resolution. OMI is a nadir-viewing spectrometer aboard the NASA Aura satellite covering UV wavelength from 270nm to 380nm. Average of EDD values from OMI pixels matched within the city area was assigned as the daily mean EDD level for the corresponding city.

We used R to assess the associations of meteorological factors (including temperature, relative humidity and UV radiation) with the spread ability of COVID-19. In particular, we averaged daily temperature, maximum temperature, minimum temperature, relative humanity and UV radiation (EDD data) from early January to early March for 224 cities. Multiple regression methods were used to explore the association of meteorological factors with cumulative incidence rate and R_0 in the same period.

Results

Among the 224 cities, the mean ± standard deviation and range were (5.9±7.5, -17.8-22.0°C) for temperature and (1332.5±594.0, 385.3222.0J/m^2) for EDD. Temperature and

EDD tended to decrease toward high latitude and altitude. The mean ± standard deviation and range were (60.3±324.0, 1.9-4509.1/10^6) for cumulative incidence rate in 224 cities and (1.4±0.3, 0.6-2.5) for R_0 in 62 cities. The top 3 cities with the highest R_0 and top 15 cities with highest cumulative incidence rate were all in Hubei Province.

After adjustment for relative humidity and UV, as shown in Figure 1 left panel, temperature held no significant associations with cumulative incidence rate (χ^2=5.03, p=0.28) or R_0 (χ^2=0.93, p=0.92), in cities both outside (green points) and inside Hubei (blue points), which indicated that the spread ability of COVID-19 would not change with increasing temperature. Similarly, as shown in Figure 1 right panel, UV was not significantly associated with cumulative incidence rate (χ^2=5.50, p=0.24) and R_0 (χ^2=0.91, p=0.92) after adjustment for temperature and relative humidity, suggesting that the spread ability of COVID-19 would not change with increasing UV exposure. In addition, we did not find significant associations of relative humanity, maximum temperature and minimum temperature with cumulative incidence rate or R_0 of COVID-19.

Discussions

Previous results on the relationship between respiratory-borne infectious diseases and temperature indicated that both SARS and influenza need to survive under certain temperature conditions, and increasing temperature can reduce the ability of SARS virus and influenza virus to spread[6, 7]. The underlying hypothesis for why warmer seasons tends to decrease the spread of viruses includes higher vitamin D levels, resulting in better immune responses[8]; increased UV radiation; and no school in the summer (when children are clustered together, transmission rates of flu and measles increase). Reports of UV and respiratory diseases have also been studied, and previous studies have shown that high levels of UV exposure can reduce the spread of SARS-COV virus[9].

The results from this study, however, do not follow this expected pattern. According to the current results, cumulative incidence rate and R_0 of COVID-19 held no significant associations with ambient temperature, suggesting that ambient temperature has no significant impact on the transmission ability of SARS-CoV-2. This is quite similar with MERS epidemic in the Arabian Peninsula where MERS cases continue when temperatures are 45°C [10]. Other newly emergent zoonotic disease, such as Ebola or pandemic strains of influenza, have also occurred in unpredictable patterns. Even though the transmission of SARS, which began in November, 2002, and ended in July, 2003, suggests it might be seasonal, but it also might have been controlled by effective case finding, contact tracing and quarantine.

Our study has limitations. First, our study period may not represent a whole meteorological pattern associated with transmissibility of COVID-19. However, we did not observe reduced transmissibility of COVID-19 in some southern Chinese cities (e.g. Sanya, Haikou, and Danzhou) with average daily temperature already over 20℃ (maximal temperature > 30℃), suggesting the robustness of our findings. Certainly, further studies with longer follow-up period and wider temperature range are warranted. Second, given the ecological nature of study, other city-level factors, such as implementation ability of COVID-19 control policy, urbanization rate, and availability of medical resources, may affect the transmissibility of COVID-19 and confound our findings. Future studies should develop complicated models with high spatial-temporal resolution to assess the relationship between meteorological conditions and epidemiologic characteristics of COVID-19.

In summary, our study does not support the hypothesis that high temperature and UV radiation can reduce the transmission of COVID-19. It might be premature to count on warmer weather to control COVID-19.

Author contributions

Ye Yao, Weibing Wang, and Haidong Kan designed the study. Jinhua Pan, Zhixi Liu, Ye Yao, and Weibing Wang collected COVID-19 incidence data and gained insight into the biology and natural history of the virus. Jinhua Pan, Zhixi Liu., Ye Yao and Weibing Wang developed the model and obtained the related parameters. Weidong Wang and Haidong Kan collected meteorological factors. Ye Yao, Jinhua Pan, Zhixi Liu, and Xia Meng drafted the manuscript. Haidong Kan and Weibing Wang revised the manuscript. All authors critically reviewed and approved the final version of the manuscript.

Competing interests

The authors declare no competing interests.

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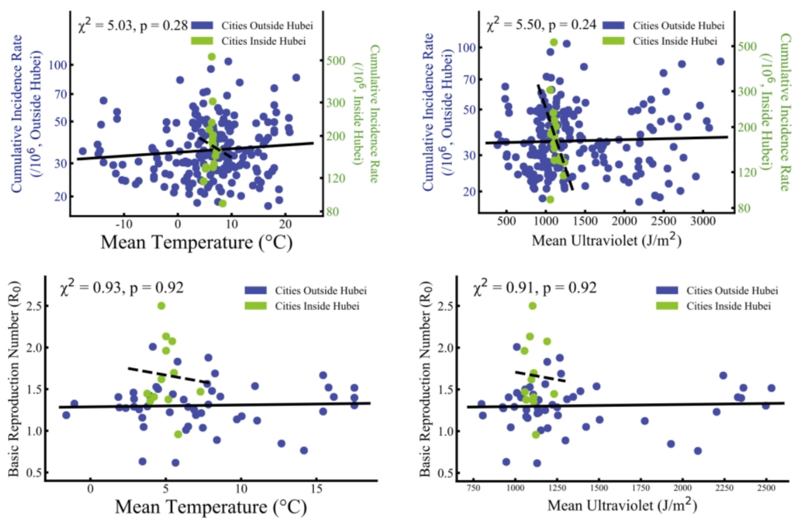

Figure 1 Temperature, Ultraviolet and Spread Ability of COVID-19"Left Panel: Cumulative incidence rate and Basic Reproduction Number (R0) hold no significant associations ($\chi^2=5.03$, $p=0.28$ & $\chi^2=0.93$, $p=0.92$) with temperature in cities outside (blue points) and inside Hubei (green points). Relative humidity and ultraviolet effects have been adjusted in the model."Right Panel: Cumulative incidence rate and R0 hold no significant associations $\chi^2=5.50$, $p=0.24$ & $\chi^2=0.91$, $p=0.92$) with ultraviolet in cities outside and inside Hubei. Temperature and relative humidity effects have been adjusted in the model.