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Dear Editor,

We read with great interest the well-presented article titled “Temperature significantly changes COVID-19 transmission in (sub)tropical cities of Brazil” by Prata et al. (2020), analyzing the temperature data sampled from 27 cities in Brazil from February 27th to April 1st, 2020 found that temperature had a negative linear relationship with the number of confirmed coronavirus disease 2019 (COVID-19) cases. A broadly similar point has also recently been made by other studies (Tosepu et al., 2020; Xie and Zhu, 2020). However, this notion is judged as Brazil recently jumped to the second place of COVID-19 cases in the world, although the high temperatures. On the other hand, after rejected lockdown measures, hard-hit Brazil removes data amid rising death toll (Prazeres, 2020). In that context, there are several caveats to interpreting high incidence and mortality rates in Brazil.

Additionally, to the study of Prata et al. (2020), we aimed to assess the impact of multiple climatological parameters including daily maximum, average and minimum temperature, dew point temperature, humidity, wind speed and sea-level pressure values on daily and cumulative COVID-19 incidence and mortality in 27 states of Brazil from February 26th, 2020 to May 31st, 2020, according to data collected before the “statistical coup” by the Brazilian government on 5th June 2020 (Prazeres, 2020). COVID-19 cases data were collected by the Johns Hopkins Coronavirus Resource Center for the period starting from February 26th, 2020 to July 19th, 2020 (Johns Hopkins Coronavirus Resource Center, 2020).

The maximum, average, minimum temperature, dew point temperature, relative humidity, wind speed, and sea-level atmospheric pressure data were recorded for the same period at the state level by the Weather Underground (2020) website, providing local and long-range weather conditions. The population density was calculated by the number of individuals per unit area (Wikipedia, 2020). Bi-variate analyses of correlations of numerical data between groups were tested by Pearson’s R Correlation. Receiver operating curve (ROC) analysis was used to determine the best cutoff point for temperature by measuring the area under the curve (AUC). Stepwise multiple linear regression was used to explain the relationship between average daily or cumulative COVID-19 cases or deaths and meteorological variables. A result was considered statistically significant when the p-value was <0.05. Data were analyzed using IBM SPSS Statistics 23.

The most important linear relationships between meteorological conditions and COVID-19 daily and cumulative incidence or mortality, as were indicated by a correlation coefficient, are presented in Table 1. We found that daily maximum temperature was weakly inversely correlated with daily confirmed new or cumulative COVID-19 cases and daily confirmed new or cumulative COVID-19 deaths. No linear correlation or a very weak linear correlation were found between average humidity and daily or cumulative COVID-19 incidence or mortality. A very weak or weak negative correlations were found between dew point temperature and daily or cumulative COVID-19 incidence or mortality. A very weak positive correlation was found between average wind speed and daily or cumulative COVID-19 incidence or mortality. Average sea-level atmospheric pressure was weakly positively correlated with daily and cumulative COVID-19 incidence or mortality.

It has been recently supported that the median incubation period for COVID-19 is approximately five days (95% CI, 4.5 to 5.8 days) (Lauer et al., 2020). Considering the lag of 5 days for virus incubation, five-day earlier infection time point was used for correlation analysis, showing similarly, not appreciable correlations between meteorological variables and daily or cumulative COVID-19 incidence or mortality (Table 2).

Prata et al. (2020) supported a single threshold of the temperature effect on COVID-19 incidence at 25.8 °C. ROC curve analyses demonstrated bad AUCs indicating that temperature alone is a poor predictor of daily COVID-19 incidence (AUC = 0.608, CI 95% 0.571–0.644) or mortality (AUC = 0.592, CI 95% 0.557–0.628) and cumulative COVID-19 incidence (AUC = 0.685, CI 95% 0.653–0.716) or mortality (AUC = 0.678, CI 95% 0.646–0.709) (Fig. 1). Similar results were also obtained when conducting the analysis in the earlier time-point of five days.

A multiple stepwise regression analysis was subsequently performed to assess the effects of multiple factors (daily maximum, average and minimum temperature, dew point temperature, humidity, wind speed, sea-level pressure, and density) on daily and cumulative COVID-19 incidence and mortality (dependent variables). The effects of maximum temperature and dew point temperature, density, average wind speed, and sea-level pressure that were finally used as the independent variables in the prediction of the new daily confirmed or cumulative COVID-19 cases or deaths were statistically significant (p < 0.05); however, these independent predictors explained only 10–20% of the total variance in the regression models (R2 = 10–20%).

Our findings should be put into context with other critical factors such as the seasons change from summer to winter, the testing delays, the differences in quality of living conditions, and the prevention policies taken by the Governments (Kretzschmar et al., 2020). The vast majority (97.5%) of those who develop symptoms will do so within 11 days (CI, 8.2 to 15.6 days) of infection. The testing delays should be considered on a case-by-case basis. Nevertheless, it has been very recently documented that around 40% of transmission occurs before symptom onset; thus, keeping the time between symptom onset and testing and isolation of an index case short (<3 days) is imperative for successful contact tracing.

The pandemic has triggered a variety of responses from federal, state, and local governments, having an impact on politics and the public’s health. The ethic of truth in politics has no temperature. On April 6th, 2020, the President Jair Bolsonaro threatened to fire the popular Health Minister, Luiz Henrique Mandetta, after the lateral criticized...
that the President has repeatedly downplayed the severity of the outbreak, shrugging off social distancing recommendations (Politica, 2020a). On April 16th, 2020, he fired him, over disagreements about social distancing guidelines (Politica, 2020b). When the President was asked about the rapidly increasing numbers of COVID-19 cases, he responded: “So what? What do you want me to do?” (The Lancet, 2020).

Bad politics led Brazil to overtake China in the number of confirmed cases two months after the first confirmed case on 25 February. Today, Brazil seems to have 2,166,532 confirmed cases and 81,597 deaths, but the myth behind all truth is that on June 8th, 2020, Brazil’s Health Ministry stopped publishing COVID-19 case and death data. Undoubtedly, the facts showed that the bad policy had no temperature and could be more dangerous than a virus. Further experimental and epidemiological studies are urgently needed to evaluate the ongoing COVID-19 pandemic, which constitutes a multifactorial problem requiring multifactorial responses.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Authors’ contributions

OSK conceived of the presented idea. OSK edited the manuscript. TZ assisted in data collection. OSK analyzed the data and produced the draft figures. KIG critically evaluated the final draft. All authors approved the final version of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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*Table 1*

Correlations between meteorological conditions and coronavirus disease 2019 (COVID-19) daily and cumulative incidence or mortality.

|                         | Max temperature (°C) | Max dew point temperature (°C) | Average humidity (%) | Average wind speed (mph) | Average sea-level atmospheric pressure (Hg) |
|-------------------------|----------------------|--------------------------------|----------------------|--------------------------|--------------------------------------------|
| Daily confirmed new COVID-19 cases Pearson correlation | -0.239               | -0.075                         | -0.100               | 0.145                    | 0.216                                      |
| p-Value                 | <0.001               | <0.001                         | <0.001               | <0.001                   | <0.001                                     |
| Cumulative COVID-19 cases Pearson correlation         | -0.311               | -0.200                         | -0.100               | 0.139                    | 0.203                                      |
| p-Value                 | <0.001               | <0.001                         | <0.001               | <0.001                   | <0.001                                     |
| Daily new COVID-19 deaths Pearson correlation        | -0.201               | -0.029                         | -0.134               | 0.187                    | 0.230                                      |
| p-Value                 | <0.001               | 0.218                          | <0.001               | <0.001                   | <0.001                                     |
| Cumulative COVID-19 deaths Pearson correlation       | -0.289               | -0.020                         | -0.100               | 0.150                    | 0.207                                      |
| p-Value                 | <0.001               | 0.250                          | <0.001               | <0.001                   | <0.001                                     |

*Fig. 1.* Receiver operating curves (ROC) to assess temperature as a predictor of higher daily new and cumulative COVID-19 incidence and mortality.

*Table 2*  

Correlations between meteorological conditions and coronavirus disease 2019 (COVID-19) daily and cumulative incidence or mortality, using a five-day earlier infection time point considering the lag effect.

|                         | Max temperature (°C) | Max dew point temperature (°C) | Average humidity (%) | Average wind speed (mph) | Average sea-level atmospheric pressure (Hg) |
|-------------------------|----------------------|--------------------------------|----------------------|--------------------------|--------------------------------------------|
| Daily confirmed new COVID-19 cases Pearson correlation | -0.177               | -0.142                         | -0.085               | 0.100                    | 0.167                                      |
| p-Value                 | <0.001               | <0.001                         | <0.001               | <0.001                   | <0.001                                     |
| Cumulative COVID-19 cases Pearson correlation         | -0.226               | -0.211                         | -0.111               | 0.102                    | 0.159                                      |
| p-Value                 | <0.001               | <0.001                         | <0.001               | <0.001                   | <0.001                                     |
| Daily new COVID-19 deaths Pearson correlation        | -0.190               | -0.162                         | -0.143               | 0.141                    | 0.240                                      |
| p-Value                 | <0.001               | <0.001                         | <0.001               | <0.001                   | <0.001                                     |
| Cumulative COVID-19 deaths Pearson correlation       | -0.224               | -0.208                         | -0.152               | 0.134                    | 0.214                                      |
| p-Value                 | <0.001               | <0.001                         | <0.001               | <0.001                   | <0.001                                     |
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