Original Article

Ecological Study of the Association between Coronavirus Disease 2019 Pandemic with Socioeconomic, Geographic, and Public Health Factors

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ABSTRACT

Background: The emergence of coronavirus disease 2019 (COVID-19) in Wuhan, China, in December 2019 has raised questions, especially with regards to the socioeconomic, geographic, and public health factors driving the pandemic. We studied the socioeconomic, geographic, and public health factors driving the pandemic using country level data.

Methods: We used the readily available data on the global distribution of COVID-19 cases, deaths, and tests conducted as of May 31, 2020. We examined scatter plots of country-by-country data on various socioeconomic indices, geographic data, and data on public health interventions. Pearson correlation coefficient and coefficient of determination were used to assess the strength of relationships.

Results: Highly statistically significant linear relationships were found between the logarithm of COVID-19 cases per million population and average yearly temperature in degree Celsius, the logarithm of COVID -19 tests per million population, the logarithm of gross domestic product, life expectancy, human development index, and health index.

Conclusions: whereas countries with high socioeconomic indices reported more cases and mortalities of COVID -19, there is need for further investigation into the role of geographic factors in driving the pandemic.

Key words: Ecology, COVID-19, gross domestic product, temperature, human development index

INTRODUCTION

A novel coronavirus disease was first reported in Wuhan , China , in December 2019 when Chinese authorities noticed cases of pneumonia linked to the animal market in Wuhan [1]. The disease was named coronavirus disease 2019 (COVID -19) by the World Health Organization (WHO) in February 2020 [2], declared a public health emergency of international concern in March 2020, and a pandemic in April 2020[3]. Since its emergence , it has spread to more than 200 countries worldwide , and several measures are being implemented by national and international organizations to mitigate the impact of the pandemic.

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), the causative organism of COVID-19 , belongs to the family Coronaviridae [4]. The positive - strand RNA virus phylogenetically differs from previously known coronaviruses isolated in animals and humans[5].

Most clinical and epidemiological reports on COVID - 19 focus on a single country limiting our knowledge of the global burden of the disease in terms of the role of socioeconomic , geographic and public health factors driving the pandemic[6-9]. This knowledge gap therefore could hamper the public health efforts aimed at controlling the pandemic.

Understanding the factors associated with variations in the spread of the COVID -19 across the globe is essential in demystifying the reasons why certain countries exhibit higher number of cases and mortalities compared to others . To determine whether socioeconomic and geographic factors play a role in the disease burden of COVID -19 across the globe , we conducted an ecological study to investigate the socioeconomic , geographic , and public health factors driving the pandemic.

METHODS

Using the readily available data on the global distribution of COVID -19 cases , deaths and tests conducted in 215 countries and territories in all regions in all the continents of the world as of 31 st May 2020 [10], we examined scatter plots of country level data on various socioeconomic indices such as gross domestic product (GDP) per capita (current : US $) [11], health index [12] , life expectancy [13] , and human development index (HDI)[13] . Geographic data for countries such as temperature [14], humidity [15] and latitude [16] were also examined . Other useful country level data such as time duration between appearance of the first case of COVID -19 and institution of lockdown measures were also examined in relation to COVID - 19 cases and deaths [17] . We perform logarithmic transformations of the dependent variables and some independent variables where necessary to obtain a better fit . The plots were examined for lack of fit and the residual plots were used to check for validity of linear regression model assumptions . We conducted outlier analysis using Mahalanobis and Jackknife distances . Pearson correlation coefficient (r) and coefficient of determination (R 2) were used to assess the strength of relationships . All analyses were conducted using JMP Pro software (JMP Version 12.0.1, SAS Institute Inc., Cary, NC, USA).

RESULTS

Plotting the country level data of 215 countries and territories , highly statistically significant linear relationships with 26 % to 52 % of the variance in the response variables explained by the explanatory variables were found between logarithm of COVID - 19 cases per million population and average yearly temperature in degree Celsius (R2=0.2628) (Figure 1 a), the logarithm of COVID -19 tests per million population (R2=0.5249) (1b), HDI (R2=0.4299) (1 c), the logarithm of most recent GDP (R2=0.4146) (1d), life expectancy (R2=0.3601) (1e), and health index (R 2 =0.3733) (1f).

A medium correlation with 16% of the variance in the response variable explained by the explanatory variable was found between logarithm of COVID -19 cases per million population and latitude (r=0.4097 , p =0.0003, R 2=0.1679).
However , small correlation with 7% of the variance in the response variables explained by the explanatory variables was found between logarithm of COVID -19 cases per million population and delay in instituting lockdown (r= 0.2732 , p = 0.0136 , R 2= 0.0746) and average humidity in February 2020 (r=0.2715 , p<0. 0004, R2=0.0737).

Strong correlation was found with 41%, 42%, 36% and 36 % of the variance in the response variables explained by the explanatory variables respectively between the logarithm of COVID -19 mortality per thousand population and HDI (r=-0.6458, p<0.0001, R2=0.4171), the logarithm of most recent GDP (r=-0. 6512, p<0.0001 , R2=0.4241), life expectancy (r=-0. 6014, p<0.0001, R2 =0.3617), health index (r=-0.6063 , p<0.0001 , R2=0. 3676).

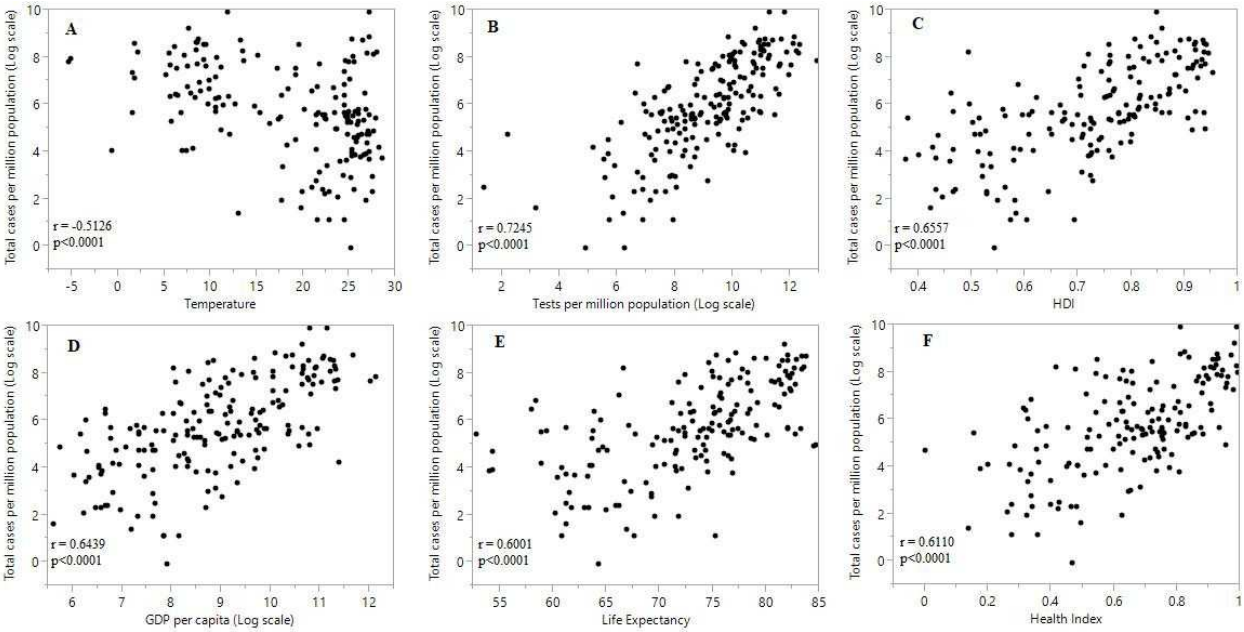

Figure 1: COVID-19 Cases and socioeconomic, geographic, and public health factors. COVID-19 cases of 215 countries and territories as at May 31 2020 were plotted against estimates where available, of (a) Average yearly temperature, (b) Tests per million population (log scale), (c) Human development index, (d) Most recent gross domestic product (US$, log scale), (e) Life expectancy, (f) Health index

DISCUSSION

Our study has shown the association between COVID -19 and socioeconomic, public health and geographic indices. We have demonstrated that more cases of COVID-19 will be uncovered by scaling up testing. Delay in instituting lockdown is also associated with more cases. Countries with better socioeconomic indices reported more cases and mortality from COVID-19.
Higher atmospheric temperature is associated with less cases and vice versa for humidity.

Based on our findings, countries that conducted more tests were able to uncover more cases of COVID -19. This finding is in keeping with recommendations of WHO that countries should test, test and test individuals suspected to have the disease [18]. Interestingly , 52 % of the variance in cases between countries was explained by their ability to conduct more tests. The public health implication of this finding is that countries should roll out COVID-19 testing in order to improve case detection and management.

Similar to our findings, a study conducted in China suggested that more stringent lockdown measures have the potential to slow down the spread of COVID -19[19]. However, only 7% in the variance of cases between countries is explained by lockdown measures.

The positive correlation between higher socioeconomic indices and reported cases is not surprising. Moreover, 41 % of the variance in cases between countries was explained by their GDP. Countries with better socioeconomic indices conduct more tests and are better organized to report cases and mortalities compared to their counterparts with lower socioeconomic indices. This finding lays credence to the role funding availability in mounting effective responses against COVID-19.

The inverse correlation between atmospheric temperature and number of cases, may be because higher temperature could denature viral particles on surfaces limiting disease spread [20,21,22]. This finding should be interpreted with caution and investigated further.

The major limitation of this study is the fact that COVID -19 is still evolving in certain countries . Furthermore , as with all ecological studies , associations at aggregate level may not be true at the individual level and migration into and out of countries may bias the results.

In conclusion , we found statistically significant linear relationships between the logarithm of COVID -19 cases per million population and average yearly temperature in degree Celsius , the logarithm of COVID-19 tests per million population , the logarithm of gross domestic product , life expectancy , human development index, and health index.

Whereas countries with high socioeconomic indices reported more cases and mortalities of COVID- 19, there is need for further investigation into the role of geographic factors in driving the pandemic.

DECLARATIONS

Competing interests: None.

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Authors 'contributions : DFM , IG , HMA and HAG conceived and designed the study. DFM conducted literature search . DFM , IG , HMA and HAG performed data acquisition while DFM conducted data analysis. DFM, IG, HMA and HAG drafted and reviewed the manuscript for scientific content and accuracy of statistical analyses.

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