Factors affecting the death toll of COVID-19 (SARS-CoV-2): evidence from 166 countries

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Article Info

Article history:

Received Oct 16, 2021
Revised May 9, 2022
Accepted Jun 21, 2022

Keywords:

COVID-19
Death
Region
Regression
Temperature

ABSTRACT

This study investigated the factors that affect the death toll of the COVID-19 on a global scale. This study employed secondary data (Cross-sectional data) collected for 166 different countries and used both descriptive statistics and regression analysis to analyze the collected data and to address the predefined objective. The ordinary list square (OLS) regression result depicted that temperature has a negative and statistically significant effect on the death toll of COVID-19. On the other hand, the population size and the total number of cases have a positive and statistically significant effect on the death toll of COVID-19. Likewise, the geographical region has a statistically significant effect on the death toll of COVID-19. Based on the findings, this study concludes that temperature variation, regional difference, and population size have a significant effect on the death toll of COCID 19 and shall be considered by governments and policymakers to tackle COVID-19 mortality.

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1. INTRODUCTION

A novel coronavirus infection (COVID-19) pandemic capable of infecting humans was discovered in Wuhan, China, in December 2019, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [1]–[3] which quickly expanded across both developed and underdeveloped nations [1], [4]. Coughing, fever, tiredness, and difficulty breathing are all frequent symptoms of COVIDA-19 [5], [6]. Although other symptoms such as a sore throat, diarrhea, muscular discomfort, nasal congestion, and a new loss of taste or smell are conceivable [7], [8]. SARS-CoV-2 has a substantially greater infectivity potential than other coronaviruses, such as SARS-CoV and middle east respiratory syndrome-corona Virus (MERS-CoV), allowing it to spread fast over the world and become a worldwide pandemic [9], [10], has established it as the 21st century's most serious worldwide health and economic problem [11], [12]. Worse, its evolution is impossible to predict [13] SARS-CoV-2 is more lethal than previously emerging coronaviruses due to its high mortality rate [11], [14].

Coronavirus has killed countless individuals all around the world since its announcement in China, and the world has become a radically different place as a result [15]. Thus, the World Health Organization (WHO) has classified the Coronavirus disease (COVID-19) as a global pandemic on 11 March 2020 [16] as it has an unusually fast rate of spreading and killing more people around the world [17]–[19]. As of November 22, 2021, the death from COVID has been surpassed 5,150,873 people with more than 257,560,010 confirmed cases worldwide (COVID-19 dashboard: WHO, 2020 and COVID-19 Dashboard: Johns Hopkins University [20]. These deaths are not uniformly distributed, and several counties are experiencing higher-than-average death rates [21], where all European countries were hit, with some countries like Italy being hit very hard [22], whereas others like Latvia, Greece, or Bulgaria and African countries had much lower death rate. Such rapid rises in the number of infected individuals and confirmed death imply that it is crucial to conduct scientific studies to understand why such differences exist, to identify the factors that determine the death from COVID-19, and how to plan for optimal actions.

Numerous researches have been carried out to determine the elements that contribute to the spread of COVID-19, including social, economic, physical, and environmental aspects [23], [24]. Several researchers studied the influence of temperature and humidity on COVID-19 transmission, finding that temperature is inversely related to COVID-19 incidence, but their impacts on death had not been recorded [25]–[31]. As a result, we believe that meteorological circumstances may have had a role in COVID-19's death. A research done in Wuhan, China to evaluate the effects of temperature fluctuation and humidity on COVID-19 death found a positive relationship between COVID-19 daily death counts and diurnal temperature range, but a negative relationship for relative humidity [1].

The other essential consideration in the COVID-19 pandemic is why the COVID-19 fatality rate varies so much from country to country [32]. Differences in COVID-19 testing might be one factor. According to Liang *et al*. 2020, the COVID-19 death rate is adversely related to the COVID-19 test number, and this relationship is significantly higher among low-income nations and countries with the lowest government performance scores, the lowest percentage of elderly people, and the fewest beds [33]. These findings showed that increasing the number of COVID-19 tests available and improving government efficiency might reduce COVID-19-related mortality. States in the United States with high population density and testing have consistently high infection and mortality rates [34]. Aside from geographic variances in reported case-fatality ratios, changes in testing techniques may also be reflected; counties with relatively high rates of mortality may be ones where testing has been more limited and restricted to the most critically ill [35].

A study of the socioeconomic determinants of COVID-19 mortality at the county level indicated that a larger percentage of poor individuals, higher density, and higher population were all independently and substantially related with a higher number of fatalities across all counties [36]. Baqui *et al*. looked at racial and geographical disparities in COVID-19 in-hospital mortality in Brazil and observed significant regional variability in both case characteristics and outcomes. The proportion of hospitalized patients followed a similar pattern, with a greater proportion in the north than in the central-south (assuming a spatial impact) and a higher proportion among Black and Pardo Brazilians than in other ethnic groups (implying an ethnicity influence) [37]. Filipa Sá (2020) discovered a link between infection and death rates and the number of black or Asian residents in the local authority. This association is stronger in the case of death than in the case of infections [38].

Generally, many studies have been conducted from the first report of the pandemic to identify the factors that determine the COVID-19 fatality rate across the world using by applying different methods at different levels [1], [3], [37], [38]. Thus, this study aimed to identify factors that exerted an effect on the mortality rate because of the COVID-19 outbreaks and its difference among countries at the global level, by employing econometric methods of analysis and adding evidence to the existing scientific literature.

2. HYPOTHESIS

Based on the empirical and theoretical studies reviewed this study developed and tested the following research hypotheses:

H1: Temperature variation has a negative effect on the death toll of COVID-19.
H2: Geographic region has a significant effect on the death toll of COVID-19.
H3: The population size has a positive effect on the death toll of COVID-19.
H4: The number of cases has a positive effect on the death toll of COVID-19.

3. RESERACH METHOD

3.1. Research design

The purpose of this study is to provide a clear snapshot of the outcome at a specific point in time of the death toll of COVID-19 and of the factors that contribute to the differences between nations rather than the process of change. We, therefore, used a cross-sectional study design to make causal inferences regarding the death toll of the COVID-19 (SARS-CoV-2) pandemic.

3.2. Data source and method of analysis

This study employed secondary data (Cross-sectional data) collected for 166 different countries from the John Hopkins University (https://coronavirus.jhu.edu/map.html), United Nation Population Division, Nuclear Threat Initiative (NTI), and an Economist Intelligence Unit (EIU). To interpret the data and discuss the predefined goal, the study used both descriptive statistics and regression analysis. The descriptive statistics made by using measures of dispersion like mean, maximum, minimum, standard deviations variance, and other simple statistical tools that enable to better understand the existing situation and analyze the general trends of the data, which substantiated through manipulating econometric model to examine the causal relationship between the explanatory and dependent covariates.

3.3. Specification of the model

To examine the raw data and determine the connection between endogenous and exogenous components, this study used ordinary list square (OLS) regression. The connection between one or more independent factors and a dependent variable can be estimated using OLS regression [39]. The fact that the dependent variable is continuous is an implicit assumption in OLS regression, and in our situation, the explanatory variable is the log of total death, which is a continuous variable. Following its potential to help researchers in swiftly and efficiently interpreting research, the study employed the computer software program EView-9 for data analysis. To characterize the effect of explanatory factors on the dependent variable, the study offered the following econometric models (1).

$$LTD_i = \beta_0 + \beta_1 \text{TEM} + \beta_2 \text{GHSI} + \beta_3 REG + \beta_4 \text{LTP} + \beta_5 LTC + U_i \quad (1)$$

Where: the log of total deaths (LTD), the Temperature (TEM), the Global Health Security Index (GHSI), stands for the region (REG), the log of the total population (LTP), the log of total cases (LTC), and β_1, β_2, β_3, β_4, and β_5 are the coefficients for each independent variable in the model, u_i is the error term as shown in Table 1.

Table 1. Description of variables

Variable	Description
Log of total deaths (LTD)	The total number of COVID-19 confirmed deaths
Temperature (TEM)	Measures the weather parameter or it is the kinetic energy, or energy of motion, of the gases that make up air.
Global Health Security Index (GHSI)	Comprehensive assessment and benchmarking of health security and related capabilities across the world
Log of the total population (LTP)	All usual residents of the country or all persons present in the country at the time of the census.
Log of total cases (LTC)	The total number of COVID-19 confirmed cases
Geographic region (GR)	Asia=1; Europe=2; Arab=3; Africa=4; South America=5; North America=6; Middle East=7

Note: the log of total death is the dependent variable

4. RESULT AND DISCUSSION

4.1. Descriptive analysis

As presented in Table 2, out of the total 166 different countries, 43 (25.9%) of them are from Europe. Hence, 41 (24.7%) are from Africa, 35 (21.08%) are from the Asia Pacific, 23 (13.86%) are from South America, 12 (7.23%) are from the Middle East. Furthermore, 9 (5.42%) are from the Arab States and the remaining 3 (1.81%) of the sample countries are from North America.

Table 2. Descriptive statistics for the variables

	TEM	LTP	LTD	LTC	GHSI
Mean	17.82525	16.28412	6.463507	10.27483	42.69264
Median	21.40000	16.19510	6.462545	10.79524	40.60000
Maximum	28.29000	21.08744	12.39236	16.11002	83.50000
Minimum	-5.350000	12.56532	0.000000	3.178054	16.20000
Std. Dev.	8.492056	1.586921	2.342526	2.429580	14.26616
Skewness	-0.629070	0.135176	0.128976	-0.406309	0.569843
Kurtosis	2.189511	3.086835	2.815450	3.329000	2.786188
Jarque-Bera	15.11871	0.557692	0.662267	5.284040	9.132063
Probability	0.000521	0.756657	0.718109	0.071217	0.010399
Sum	2887.690	2703.163	1021.234	1695.347	6958.900
Sum Sq. Dev.	11610.52	415.5228	861.5260	968.0687	32970.79

The average number of COVID-19 related death is 7,784 people by country. As of November 5, 2020, the maximum amount of death toll is registered in the United States of America with total COVID-19 related death of 240, 953. On the other hand, Countries like Bhutan, Cambodia, Eritrea, Laos, Mongolia, Netherlands, North Korea, and Timor-Leste do not register any COVID-19 related deaths. With regards to temperature, the average temperature is 17.82 which varies between -5.3 (Russia) to 28.29 (Burkina Faso). Out of the total observation, the most populous country is China and the least populous country is the Netherland with a population size of 1,439,323,776 and 286,451respectively, which depicted a significant variation among sample countries with regards to population size. The average overall Global Health Security Index score totals 42.69 out of a possible score of 100, which indicated the Global Health Security Index score is fundamentally weak around the world. No country is fully prepared for epidemics or pandemics, and every country has important gaps to address. The 116 high and middle-income countries do not score above 50.

With regards to the association of explained and explanatory variables, the line and symbol graph of the log of total death - log of the total population and the log of total death- log of total case depicts a parallel pattern. On the other hand, the line and symbol graph of the temperature-log of total death indicate the negative association between death toll and temperature as presented in Figure 1.

4.2. Classical linear regression model (CLRM) assumptions and diagnostic tests

Several crucial diagnostic tests, such as multicollinearity and heteroscedasticity, must be conducted before to estimating the model. As a result, we used the variance inflation factor (VIF) technique to study the problem of multicollinearity for the explanatory variables, and the findings demonstrate that there is no reciprocal interaction. The error terms are considered to be heteroskedastic if their variance is not constant. The Breusch-Pagan (BP) test was utilized in this work to detect any linear form of heteroscedasticity, and the results showed that there was no substantial evidence for the presence of Heteroskedasticity in the OLS model.

4.3. Result and discussion

Table 3 presented the OLS regression results to identify the effect of exogenous on the death toll of COVID-19 around the world. The variables included in the model explained about 91 percent of the total variation on the death toll of COVID-19 which is reasonably a good fit. This implies that the explanatory variables such as temperature, Global Health Security Index, regional dummy, the log of population, and the log of total cases jointly explained about 91 percent of the total variation on the death.

Temperature, region, the log total population, and the log of total cases all had a statistically significant influence on COVID-19 mortality rates of 10%, 5%, and 1%, respectively, according to the OLS regression results. According to the model result in Table 3, the Global Health Security Index has a statistically negligible influence on COVID-19 death toll.

The results of the model revealed a negative and significant relationship between temperature and COVID-19-related mortality, implying that rising temperatures lead to a reduced COVID-19 death toll. As all other explanatory factors are maintained constant, the number of COVID-19-related deaths falls by 0.02 percent when the temperature rises by 1°C. The findings back up prior study that showed a negative relationship between temperature and COVID-19 mortality [40]–[42]. Temperature fluctuation should be recognized as a major factor determining COVID-19 mortality, according to the findings.

Table 3. OLS regression output for factors affecting the death toll of COVID-19

Dependent Variable: LOGTOTALDEATHS
Method: Least Squares
Sample: 166

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TEMPERATURE	-0.021919	0.011132	-1.968921***	0.0509
GHSI	-0.004847	0.005829	-0.831560	0.4070
AFRICA	-0.973279	0.217040	-4.484320*	0.0000
ARAB	-0.537186	0.300794	-1.785892***	0.0762
ASIA	-1.157249	0.237128	-4.880266*	0.0000
EUROP	-0.638119	0.251154	-2.540753**	0.0121
MIDDLE EAST	-0.614874	0.256090	-2.401010**	0.0176
NAMERICA	-0.310156	0.484097	-0.640691	0.5227
LOGTOTALPOP	0.338507	0.054142	6.252223*	0.0000
LOGTOTALCASES	0.820017	0.043898	18.68011*	0.0000
C	-6.375907	0.713887	-8.931261	0.0000
R-squared	0.911630	Mean dependent var		6.505709
Adjusted R-squared	0.905493	S.D. dependent var		2.332131
S.E. of regression	0.716944	Akaike info criterion		2.240685
Sum squared resid	74.01724	Schwarz criterion		2.456670
Log-likelihood	-162.6531	Hannan-Quinn criteria		2.328414
F-statistic	148.5507	Durbin-Watson stat		2.139950
Prob(F-statistic)	0.000000			

Own competition 2020
Significance level at: * (1%); **(5%) and ***(10%)

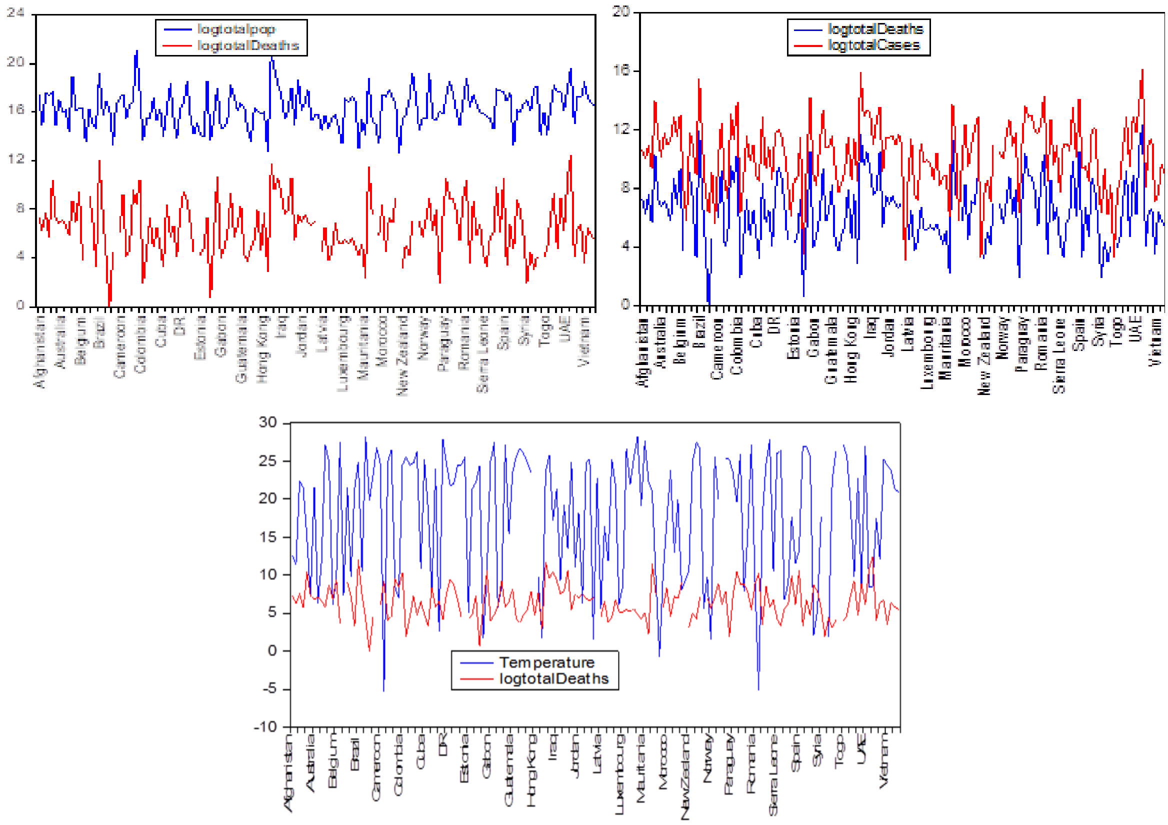

Figure 1. The line and symbol graph of temperature, the log of total cases, and log total death

The COVID-19 situation has a wide range of regional and local effects [34] having far-reaching consequences for crisis management and policy responses [43]. The proportion of total COVID-19-related death in South America is 1.15% greater than in Asia, 0.97% higher than in Africa, 0.63% higher than Europe, 0.61% higher than the Middle East, and 0.53% higher than the Arab World, according to our OLS regression results. The three areas with the highest deaths as of December 16, 2021 are America (2,379,391), Europe (1,577,371), and Asia (1,129,745) [44]. On the other hand, since the first COVID-19 case was discovered in Africa, practically all African nations have continued to record lower morbidity and death than the worldwide trend [45].

According to the regression results, population size has a positive and statistically significant impact on COVID-19 death toll, meaning that as the population grows, so does the death toll. The finding is in accordance with what was predicted and it is in line with the findings of other researches who discovers as tatstically siginifcalt positive relationship between population size and COVID-19 death toll [34]. Similarly, the total number of cases has a positive and statistically significant impact on COVID-19 death rates, indicating that an increase in total cases leads to an increase in COVID-19 death rates. If all other explanatory factors stay constant, the number of COVID-19-related fatalities will rise by 0.82% as the number of cases rises by one person. The results are consistent with predictions and conclusions from prior research [36] which found that high testing leads to consistency high infection and mortality rates, but contradicts [35] which found that the COVID-19 death rate was adversely related to the COVID-19 test number.

5. CONCLUSION

The OLS regression result depicted that temperature, region, the log total population, and the log of total cases have a statistically significant effect on the death toll of COVID-19. However, the Global Health Security Index has a statistically insignificant effect on the death toll of COVID-19. The tectonic way to minimize the death toll of COVID-19 is to minimize the spread or the number of cases of COVID-19. During a pandemic large population size adds to the inability of governments to deliver appropriate medical services and to cope up with the increasing number of infections. As a result, the previous government's initiation to control population growth should be resumed. Including our findings, many articles reviled the discrepancy between the Global Health Security Index rating and the actual performance of countries during this pandemic.

In line with the findings, the GHSI should not be considered as a measure of preparedness to tackle the impact of the pandemic and the computation method of GHSI should be revised. Besides, the study also suggests that temperature variation and regional differences be considered during and before any policy intervention.

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