Effect of Population Density and Economic Indicators on COVID-19 Death Rates in the Community of Latin American and Caribbean States

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Objective: The countries of the Community of Latin American and Caribbean States (CELAC, by its initials in Spanish) have been some of the most affected by COVID-19. This paper analyzes whether, in the 33 CELAC countries, population density, together with other economic variables, such as gross domestic product (GDP) at purchasing power parity (PPP) values or the Human Development Index (HDI), were significantly associated with the coronavirus mortality rate.

Methods: A correlation analysis and an ordinary least squares regression model were used to analyze the effects of different variables on the COVID-19 mortality rate.

Results: The results showed that countries with higher numbers of inhabitants per square kilometer had lower death rates. Gross domestic product was not associated with the number of deaths, while the HDI had a positive impact on that number.

Conclusion: Countries with high population density are not more vulnerable to COVID-19, as population density allows for economic development and better-designed institutions. [*P R Health Sci J 2022;41(4):192-196*]

Key words: COVID-19, Death rate, Population density, GDP, HDI

The rapid spread of COVID-19 has generated an unprecedented health, economic, and social crisis around the world, and has largely affected countries belonging to the Community of Latin American and Caribbean States (CELAC, using its initials in Spanish). This regional organization provides an intergovernmental mechanism for fostering the integration and individual growth of its member countries, which are spread across Latin America and the Caribbean. CELAC was created on 3 December 2011 with the mandate to advance political, economic, social, and cultural unity among its members; in addition to cultivating the overall integration of the regions, its goals include increasing the quality of life of its citizens via enhancing social welfare, promoting economic growth, and achieving sustainable development.

There are 33 CELAC member countries: Antigua and Barbuda, Argentina, the Bahamas, Barbados, Belize, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Chile, Dominica, the Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Saint Lucia, Suriname, Trinidad and Tobago, Uruguay, and Venezuela.

To curb the spread of the pandemic, many governments have taken measures such as mandating home confinement, restricting mobility, and halting non-essential services (1). In the field of education, the mode of instruction has become mostly online (2,3), and teleworking has been widely implemented by many companies (4). During the height of the pandemic, in an attempt to reduce the number of infections and deaths, many important sectors of business activity, such as hospitality and tourism, were reduced or paralyzed, leading to significant falls in the gross domestic products (GDPs) (5,6). The arrival of the first vaccines in 2021 seemed to be an important step forward in the fight against the virus (7); however, economic reconstruction (8) is also necessary in many sectors to reduce or alleviate the devastating effects of the pandemic and the crisis that COVID-19 is producing. The economies and demographics of countries are interesting aspects to study (9,10) since their specific population densities might be related to the rates of death from coronavirus as well as might the GDP and Human Development Index (HDI) of each of those countries. In this paper, we aim to measure (in CELAC countries) the association that population density and other economic variables that indicate a country's well-being (such as the GDP and HDI) may have on the COVID-19 mortality rate.

To date, it is not known whether any work has been published on the demographic situations of these 33 countries, which, apart from the overall interest that this pandemic arouses in the research and scientific community, is where the great novelty lies.

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Data and Methodology

The COVID-19 mortality rate is a variable that depends on many factors, such as the strategies adopted by countries to contain the pandemic (11), the mobility of their populations (12), and the health resources and health spending of said countries (13). However, this rate may also be associated with economic and demographic factors (14,15), none of which factors have been sufficiently explored, especially in Latin America, and with which we aim to fill this gap in the literature. This paper analyzes whether variables such as population density ("Density," in the formula at the end of this section), the GDP per capita (GDPpc) based on PPP values, or the HDI have significant effects on the total number of deaths from COVID-19 per million inhabitants ("Deaths," in the formula at the end of this section) in the 33 CELAC countries.

Gross domestic product is the most widely used measure of a country's economic growth, and the data herein were taken from the World Bank. In this paper, in order to compare the GDPs between countries, a PPP adjustment (the dollar at current international prices) was made. Some authors indicate that a high GDP is associated with lower COVID-19 mortality (16), while others indicate the opposite, with Lippi et al. (17) finding a positive association for Italian regions, and Sarmadi et al. (18) showing that countries with high GDPs had more COVID-19 cases and deaths. The HDI, developed by the United Nations Development Programme, is an indicator that measures the level of development of each country based on variables such as life expectancy, education, and per capita income. The HDI is a number that always falls between 0 and 1, and a value close to 1 indicates a country's relatively higher level of well-being. As mentioned previously, the data for each country were obtained from the World Bank.

Because COVID-19 spreads when people are in close proximity to each other (19,20), population density (number of inhabitants per square kilometer in a given country) could be one of the aspects involved in the spread. Some researchers have concluded that the spread of COVID-19 is not related to population density in the case of the USA (21) or China (22), while various studies conducted for regions in Algeria (23) and Japan (24) do so identify it as an explanatory factor for the spread of the virus. The information for the population density variable was also taken from the World Bank. All data used correspond to the latest available that have been published.

Several studies, such as those of Shahbazi et al. and Medeiros et al. (14,15), have proposed using ordinary least squares regression models to analyze the effect of the variables that may affect the COVID-19 mortality rate. Following this trail, to test the relationship between these variables, we have proposed the following multiple linear regression model to study the case of the CELAC countries:

$$\widehat{Deaths}_i = \beta_0 + \beta_1\, GDPpc_i + \beta_2\, HDI_i + \beta_3\, Density_i + \varepsilon_i$$

Results

The rate of deaths per million inhabitants varied considerably among the countries analyzed. Some countries, such as Dominica and St. Kitts, had no deaths, while the highest death rates were found in the following CELAC countries: Brazil (2,162.43 deaths/million population), Peru (2,111.14 deaths/million population), and Mexico (1,739.01 deaths/million population). The data shown are current to the end of May 2021 and were taken from Johns Hopkins University (Figure 1).

Of the CELAC countries, the highest GDPpc (based on PPP) was that of the Bahamas ($38,742), and the lowest was that of Haiti ($3,034). In terms of the HDI, Chile had the highest (0.851) and Haiti, the lowest (0.51). In terms of density, the populations of the member countries were also highly variable. Suriname and Guyana had 4 inhabitants per square kilometer, while Barbados had 667. Table 1 shows the main descriptive measures. Given that there is considerable variability in some variables, the median and the interquartile range have been calculated in addition to the mean. Of the countries analyzed, 50% had a death rate per 1,000,000 inhabitants of more than 460 and a GDP per capita in PPP of at least $15,630.

The correlations between the different variables are presented in Table 2. The variable *total deaths per million inhabitants* shows a negative correlation with population density and a positive correlation with the HDI. The highest variance inflation factor is equal to 2.21, which shows the absence of multicollinearity problems.

Before carrying out the regression analysis, the hypotheses of independence, homoscedasticity, and normality necessary to guarantee the validity of the model were verified, as was non-multicollinearity. To do so, the differences between the observed values and those predicted by the model (the errors) were studied. The Durbin–Watson statistic was equal to 1.59, so it can be assumed that the errors were independent. The assumptions of the homoscedasticity and normality of the residuals were also met (the correlation between the values of the residuals in absolute values and the predicted scores was 1.16, and the Kolmogorov–Smirnov test for normality resulted in a P value = .91).

The multiple regression analysis (Table 3) confirmed the results obtained with the correlation analysis. It should be noted that population density was found to have a negative influence: the higher the population density, the lower the number of deaths per 1,000,000 inhabitants. The GDPpc was not significantly associated with the mortality rate, while the HDI had a positive impact on the number of deaths. Those CELAC countries with high HDIs had greater numbers of coronavirus deaths.

Discussion

The global pandemic of COVID-19 has caused millions of infections and deaths worldwide, with the South American continent being one of the most affected (25).

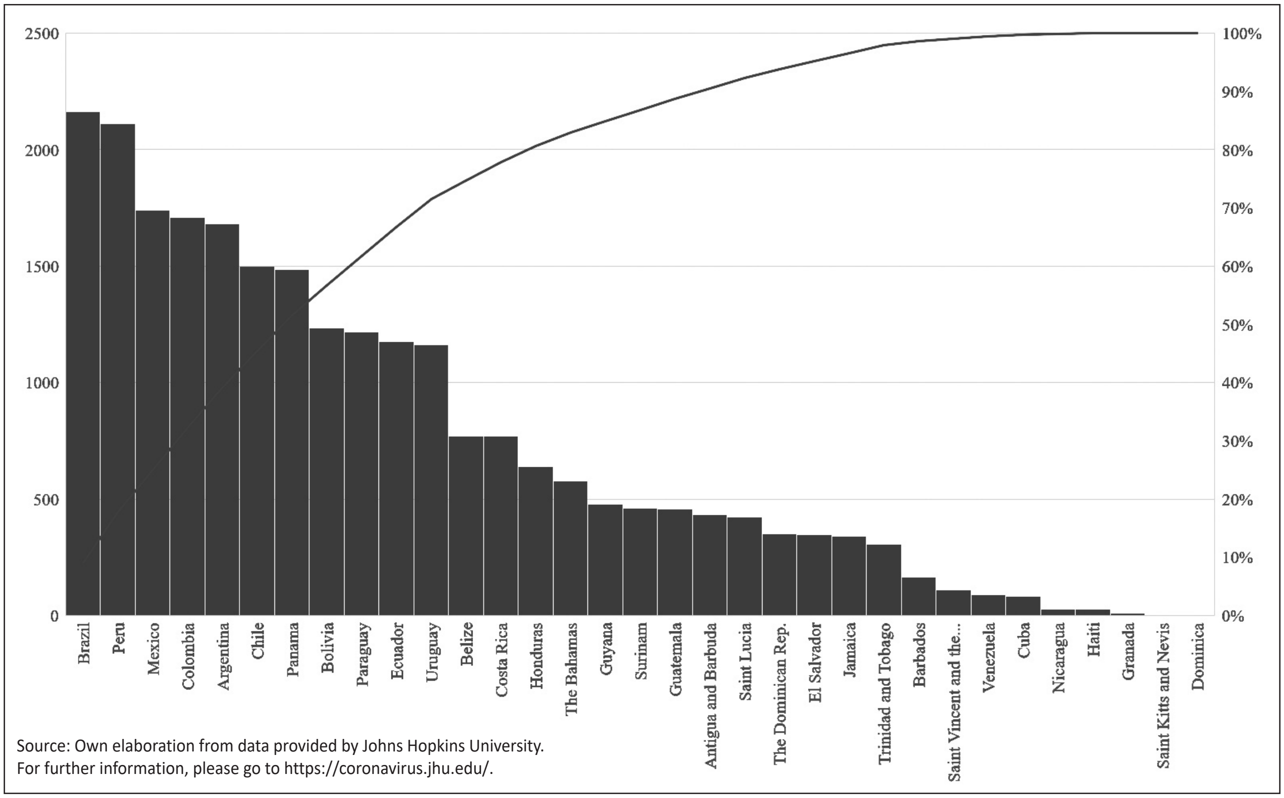

Figure 1. COVID-19 deaths per million inhabitants in CELAC countries.

In CELAC countries, the GDP per capita in PPP was not found to be significantly related to the number of deaths. The HDI had a positive association with the number of deaths. Countries with high HDIs had higher rates of coronavirus deaths, which is consistent with the literature about other geographical areas (14,26,27). The HDI is an indicator of the level of well-being of a country's population, with a greater exposure to infection being experienced by populations that enjoyed better living conditions.

The findings of this study indicated that the higher the population density, the lower the number of deaths per 1,000,000 inhabitants. These results are consistent with those obtained by Fang & Wahba (22), who discovered that Shanghai, Beijing, Shenzhen, Tianjin and Zhuhai, the cities in China with the greatest population densities, reported far fewer confirmed cases per 10,000 people than were reported by other, less densely populated cities in China; their results are consistent, as well, with the findings of Hamidi et al. (21), who reported that US counties with high densities had lower mortality rates. The cities with the highest infection rates were those with relatively low densities. In addition, these more populous cities are also those with greater economic development, which makes them better able to mobilize resources to deal with the disease and may explain, in part, their low infection rates (22).

Population density allows for economic development, which ensures better-designed institutions, high-quality infrastructure, and effective interventions to implement the social distancing that is necessary to protect cities from infectious diseases (22). The determinants of the number of infections and of death rates will also depend on other issues, such as chronic medical conditions to which a given patient may be susceptible or from which that person might already suffer (28,29).

Table 1. Main descriptive measures

Variable	Minimum	Maximum	Mean	Standard deviation	Median	Interquartile range
Deaths per 1,000,000 inhab.	0	2,162.43	728.23	662.65	460.99	1,089.89
GDPpc (PPP $)	3,034	38,742	16,499	8,131	15,630	12,109
HDI	0.51	0.851	0.748	0.068	0.759	0.073
Population density (km^2/inhab.)	4	667	136.51	150.23	68	209

GDPpc: gross domestic product per capita; HDI: Human Development Index; PPP: purchasing power parity

Among the limitations of this study is its temporality, as the data are changing and the numbers regarding the COVID-19 death rate were collected until May 2021. In addition, the association of COVID-19 mortality rates with other variables, according to the age and sex structure of the population of each country, could be further investigated, which is a potential future line of research.

Table 2. Correlation analysis of the different variables

Variable	GDPpc (PPP $)	HDI	Deaths
GDPpc (PPP $)	1		
HDI	0.737**	1	
Deaths	0.281	0.377*	1
Density	-0.117	-0.143	-0.513**

GDPpc: gross domestic product per capita; HDI: Human Development Index; PPP: purchasing power parity. *Correlation is significant at the .05 level. **Correlation is significant at the .01 level.

Table 3. Multiple regression model

Variable	Unstandardized coefficients	Standardized coefficients	*P* value
Constant	-1,898.54 (1,411.32)		.189
GDPpc (PPP $)	-0.016 (0.018)	-0.198	.360
HDI	4,375.56* (2,066.49)	0.452	.043
Density	-2.02** (0.640)	-0.499	.002

Standard errors are in parentheses. GDPpc: gross domestic product per capita; HDI: Human Development Index; PPP: purchasing power parity. ** Significant at the .01 level. * Significant at the .05 level.

Conclusions

Countries with high levels of wealth and high HDIs are likely to have an easier time investing in the development of their health systems. Restrictive measures will also need to be employed to contain the pandemic to help reduce the rate of infection and, therefore, the number of deaths. Countries with high population densities should take advantage of their potential and develop strategies to ensure that effective interventions against the pandemic are designed and put in place. We believe that all countries should try to have a certain amount of liquidity and a balanced budget, both of which would allow them to spend more money on the purchase of medical equipment and respirators, on the recruitment of medical staff, and on providing better benefits for those infected. To this end, it would be advisable for governments to also have a reserve fund that would allow them to cope comfortably with this kind if emergency.

Resumen

Objetivo: Los países de la Comunidad de Estados Latinoamericanos y Caribeños (CELAC) han sido unos de los más afectados por COVID-19. En este trabajo se analiza si, en los 33 países de la CELAC, la densidad de población, junto con otras variables económicas como el Producto Interior Bruto (PIB) en valores de paridad de poder adquisitivo o el Índice de Desarrollo Humano (IDH) se asocian significativamente con la tasa de mortalidad por coronavirus. Métodos: Se propone un análisis de correlación y un modelo de regresión por mínimos cuadrados ordinarios para analizar el efecto de las posibles variables sobre la tasa de mortalidad por COVID-19. Resultados: Los resultados muestran que los países con un mayor número de habitantes por kilómetro cuadrado tuvieron menores tasas de mortalidad. El PIB no está asociado al número de muertes, mientras que el IDH tiene un impacto positivo. Conclusiones: Los países con alta densidad de población no son más vulnerables al COVID-19, ya que la densidad de población permite un desarrollo económico con instituciones mejor diseñadas.

References

1. Wang S, Liu Y, Hu T. Examining the Change of Human Mobility Adherent to Social Restriction Policies and Its Effect on COVID-19 Cases in Australia. Int J Environ Res Public Health. 2020;17(21):7930. Published 2020 Oct 29. doi:10.3390/ijerph17217930
2. Ali W. Online and remote learning in higher education institutes: A necessity in light of COVID-19 pandemic. High Educ Stud. 2020;10(3):16-25. doi:10.5539/hes.v10n3p16
3. Cifuentes-Faura J. Docencia online y Covid-19: la necesidad de reinventarse. Rev Estilos Aprendiz. 2020;13(Special):115-127.
4. Dubey AD, Tripathi S. Analysing the sentiments towards work-from-home experience during COVID-19 pandemic. J Innov Manag. 2020;8(1):13-19. doi: 10.24840/2183-0606_008.001_0003
5. König M, Winkler A. Monitoring in real time: Cross-country evidence on the COVID-19 impact on GDP growth in the first half of 2020. Covid Econ. 2020;57:132-153.
6. Cifuentes-Faura, J. Crisis del coronavirus: impacto y medidas económicas en Europa y en el mundo. Espaço e Econ. 2020;(18). doi: 10.4000/espacoeconomia.12874
7. Laine C, Cotton D, Moyer DV. COVID-19 Vaccine: Promoting Vaccine Acceptance. Ann Intern Med. 2021;174(2):252-253. doi:10.7326/M20-8008
8. Comisión Económica para América Latina y el Caribe. Reconstrucción y transformación con igualdad y sostenibilidad en América Latina y el Caribe. October 26, 2020. Accessed March 1, 2021. https://repositorio.cepal.org/bitstream/handle/11362/46129/2000653_es.pdf?sequence=1
9. Pinzón JED. Análisis de los resultados del contagio del COVID-19 respecto a su distribución geográfica en Colombia. Repert Med Cir. 2020;29(Supl. Num. 1):59-64. doi: 10.31260/RepertMedCir.01217372.1082
10. Alvarado Batres CA, Méndez Gutiérrez LE. Determinación del índice de impacto del COVID-19 en El Salvador, por medio de la relación demográfica, ambiental y epidemiológica. Poblac Salud Mesoam. 2021;18(2). doi: http://dx.doi.org/10.15517/psm.v18i2.42242
11. Abideen AZ, Mohamad FB, Hassan, MR. Mitigation strategies to fight the COVID-19 pandemic—present, future and beyond. J Health Res. 2020;34(6):547-562. doi: 10.1108/JHR-04-2020-0109
12. Nouvellet P, Bhatia S, Cori A, et al. Reduction in mobility and COVID-19 transmission. Nat Commun. 2021;12(1):1090. Published 2021 Feb 17. doi:10.1038/s41467-021-21358-2
13. Khan JR, Awan N, Islam MM, Muurlink O. Healthcare Capacity, Health Expenditure, and Civil Society as Predictors of COVID-19 Case Fatalities: A Global Analysis. Front Public Health. 2020;8:347. Published 2020 Jul 3. doi:10.3389/fpubh.2020.00347
14. Shahbazi F, Khazaei S. Socio-economic inequality in global incidence and mortality rates from coronavirus disease 2019: an ecological study. New Microbes New Infect. 2020;38:100762. doi:10.1016/j.nmni.2020.100762
15. Medeiros de Figueiredo A, Daponte A, Moreira Marculino de Figueiredo DC, Gil-García E, Kalache A. Letalidad de la COVID-19: ausencia de patrón epidemiológico [Case fatality rate of COVID-19: absence of epidemiological pattern]. Gac Sanit. 2021;35(4):355-357. doi:10.1016/j.gaceta.2020.04.001

16. Asfahan S, Shahul A, Chawla G, Dutt N, Niwas R, Gupta N. Early trends of socio-economic and health indicators influencing case fatality rate of COVID-19 pandemic. Monaldi Arch Chest Dis. 2020;90(3):10.4081/monaldi.2020.1388. Published 2020 Jul 22. doi:10.4081/monaldi.2020.1388
17. Lippi G, Henry BM, Mattiuzzi C, Bovo C. The death rate for COVID-19 is positively associated with gross domestic products. Acta Biomed. 2020;91(2):224-225. Published 2020 May 11. doi:10.23750/abm.v91i2.9514
18. Sarmadi M, Marufi N, Kazemi Moghaddam V. Association of COVID-19 global distribution and environmental and demographic factors: An updated three-month study. Environ Res. 2020;188:109748. doi:10.1016/j.envres.2020.109748
19. Rascado Sedes P, Ballesteros Sanz MA, Bodí Saera MA, et al. Contingency plan for the intensive care services for the COVID-19 pandemic. Plan de contingencia para los servicios de medicina intensiva frente a la pandemia COVID-19. Med Intensiva (Engl Ed). 2020;44(6):363-370. doi:10.1016/j.medin.2020.03.006
20. Zamora Matamoros L, Sagaró del Campo NM, Valdés García LE, Benítez Jiménez I. Entrada de viajeros y densidad poblacional en la propagación de la COVID-19 en Cuba. Rev Cubana Med. 2020;59(3):e1375.
21. Hamidi S, Sabouri S, Ewing R. Does density aggravate the COVID-19 pandemic? Early findings and lessons for planners. J Am Plann Assoc. 2020;86(4):495-509. doi: 10.1080/01944363.2020.1777891
22. Fang W, Wahba S. Urban Density Is Not an Enemy in the Coronavirus Fight: Evidence from China. World Bank Blogs. April 20, 2020. Accessed June 8, 2021. https://blogs.worldbank.org/sustainablecities/urban-density-not-enemy-coronavirus-fight-evidence-china
23. Kadi N, Khelfaoui M. Population density, a factor in the spread of COVID-19 in Algeria: statistic study. Bull Natl Res Cent. 2020;44(1):138. doi:10.1186/s42269-020-00393-x
24. Kodera S, Rashed EA, Hirata A. Correlation between COVID-19 Morbidity and Mortality Rates in Japan and Local Population Density, Temperature, and Absolute Humidity. Int J Environ Res Public Health. 2020;17(15):5477. Published 2020 Jul 29. doi:10.3390/ijerph17155477
25. Sullivan MP, Meyer PJ. Latin America and the Caribbean: impact of COVID-19. Congressional Research Service. Updated January 21, 2022.
26. García de León Loza A. Indicadores básicos y tendencias espacio-temporales en 20 países por mortalidad COVID-19. June 6, 2020. Accessed March 1, 2021. http://ri.unlu.edu.ar/xmlui/handle/rediunlu/745
27. Liu K, He M, Zhuang Z, He D, Li H. Unexpected positive correlation between human development index and risk of infections and deaths of COVID-19 in Italy. One Health. 2020;10:100174. doi:10.1016/j.onehlt.2020.100174
28. Aguiar M, Stollenwerk N. Condition-specific mortality risk can explain differences in COVID-19 case fatality ratios around the globe. Public Health. 2020;188:18-20. doi:10.1016/j.puhe.2020.08.021
29. Ioannidis JPA, Axfors C, Contopoulos-Ioannidis DG. Population-level COVID-19 mortality risk for non-elderly individuals overall and for non-elderly individuals without underlying diseases in pandemic epicenters. Environ Res. 2020;188:109890. doi:10.1016/j.envres.2020.109890