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Association of COVID-19 global distribution and environmental and demographic factors: An updated three-month study

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ABSTRACT

We investigated the association of some environmental and economic factors and the global distribution indicators of the COVID-19 pandemic. Since the number of cases and deaths is higher in high-income countries located in higher latitudes and colder climates, further studies are required to shed light on this matter.

1. Introduction

Following the epidemic outbreak of COVID-19 in Wuhan, China, in December 2019 (Chen et al., 2020), most countries are currently in a pandemic situation. The behavior of this disease is extremely sophisticated and is the main topic of discussion in academic circles. The maps describing COVID-19 are being updated every day; however, almost all these maps have focused on the number of disease cases and the death number. At present, drawing maps and performing analyses based on other parameters such as latitude and socioeconomic factors could be useful for researchers and health policy-makers.

2. Methods

We employed the WHO report (Organization, 2020) as the main source of COVID-19 data based on the last update on April 2, 2020. Initially, the equator and the prime meridian were used for dividing the world into four parts: northeastern, northwestern, southeastern, and southwestern (Fig. 1, a). Based on primary COVID-19 data, two main variables of this study included the proportion of cases to population per 10^5 (PCP) and the proportion of death to population per 10^5 (PDP). Other parameters were the average temperature (°C) and GDP ($US) of countries, which were extracted from different websites (World Economic Outlook Database, 2019; WORLD BANK GROUP, 2020). A descriptive analysis was performed on all the data. Bivariate correlation and regression test were used to analyze the associations between socioeconomic and meteorological factors (temperature, GDP, latitude, and longitude) and the variables of COVID-19. Also, the scatter plot of log case and death rate with log GDP was drawn using SPSS. All the statistical analyses were performed at a 5% significance level .(see: Fig 1).

3. Results and discussion

The results showed that the majority of cases (533241) were observed in northeastern areas, the more COVID-19 PCP (43.26 per 10^5 people), were also appeared northeast. The pattern of PDP was similar to the case rate, and the highest death rate was found in the northeast (1.63 per 10^5). Categorizing the COVID-19 case rate based on latitude revealed that this variable is associated with the COVID-19 latitude ($r = 0.54$; $p < 001$). As it appears in Fig. 1a (the highlighted line passing through the prime meridian), in the latitude beyond 60°, a higher PCP of COVID-19, 104.54 per 10^5, is observed. Countries with a higher GDP had more COVID-19 PCP and PDP (Table 1 and Fig. 1b and c). Furthermore, temperature had a reverse association with both COVID-19 PCP ($r = -0.50$; $p < 001$) and PDP ($r = -0.50$; $p < 001$).

While discussions about the results of COVID-19 distribution throughout the globe are inconclusive, we suggest some possible reasons for these findings. Interestingly, higher COVID-19 PCP and PDP were observed in northern areas, including some parts of North America and approximately the entire Asia and Europe which are located in higher latitudes and have a colder climate and better socioeconomic condition. To interpret these results, the authors suggest

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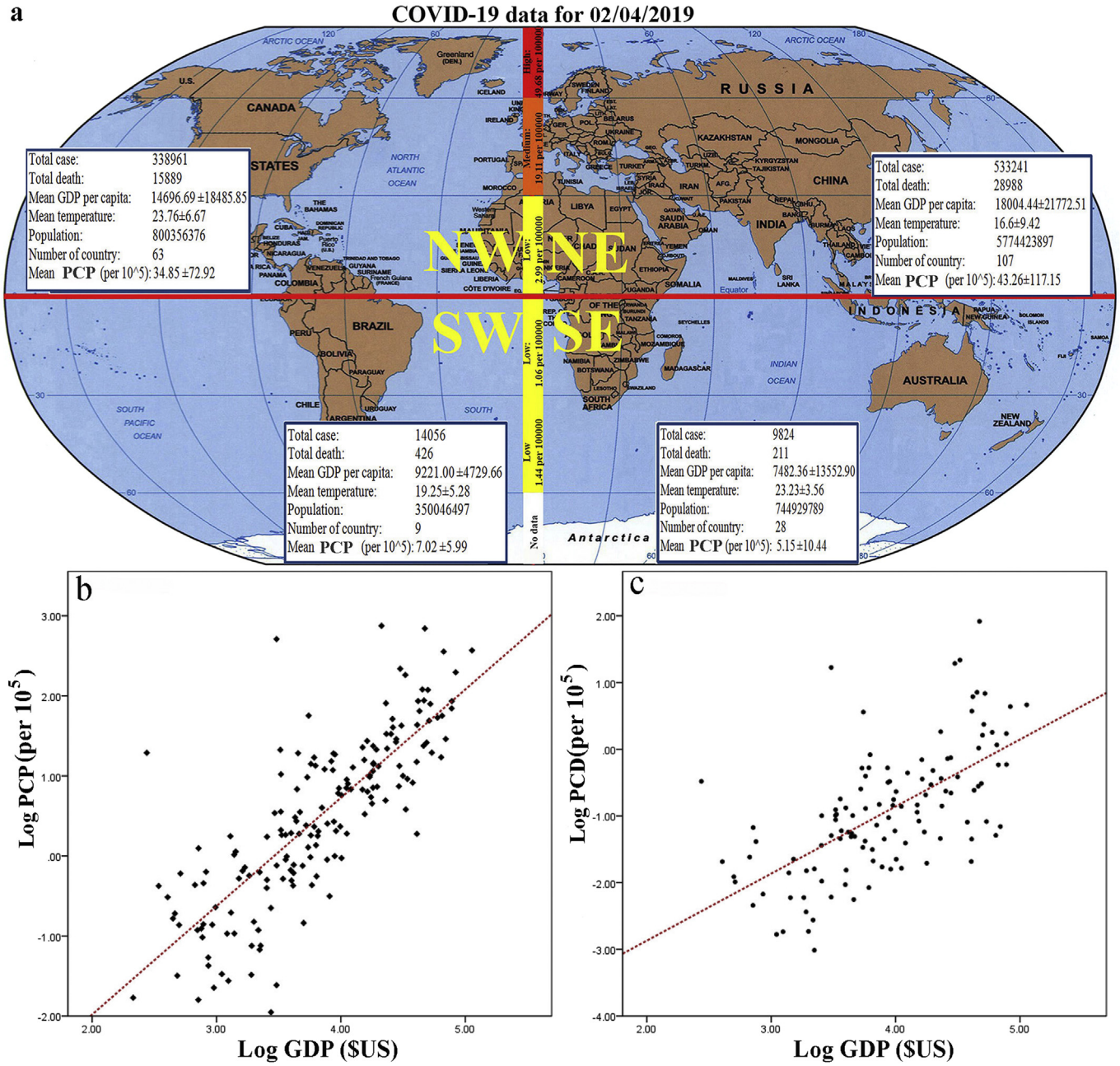

Fig. 1. Charactersistic and distribution map of COVID-19 in the world; a) category of earth and COVID-19 details in every part and proportion of cases to population per 10^5 (PCP) (highlight line) in each latitude category (0-30°, 30-60° and 60-90°), b) The correlation between Log PCP of COVID-19 with GDP per capita ($) (R = 0.799, Unstandardized Coefficients = 1.354, SE = 0.078, F = 300.587, P < 0.001), c) The correlation between Log PDP of COVID-19 with GDP per capita ($) (R = 0.630, Unstandardized Coefficients = 1.005, SE = 0.115, F = 76.518, P < 0.001).

Table 1
The correlation (r) between case and death of COVID-19 (per10^5 people) and independent variables up to April 2, 2020.

Earth category	variable	GDP per capita ($)	Temperature (°C)	Latitude (degree)	Longitude (degree)
Globally	PCP[a]	0.827**	−0.50**	0.54**	−0.16*
	PDP[a]	0.50**	−0.50**	0.38**	−0.18*
North	PCP[a]	0.82**	−0.51**	0.53**	−0.22*
	PDP[a]	0.50**	−0.46**	0.41**	−0.19**
South	PCP[a]	0.83**	−0.45*	0.39**	0.47**
	PDP[a]	0.57**	−0.25	0.054	0.12

****P < 0.01, *P < 0.05; PCP = proportion of cases to population per 10^5, PDP: proportion of deaths to population per 10^5.**

some major reasons for these data. First, the distribution patterns and the mentioned associations could be related to the availability of diagnostics kits and health care facilities (Bi et al., 2020; Coronavirus Testing, 2020). In addition, both colder climate and more densely populated areas could contribute to the spread of the disease in European and Asian megacities (Xie and Zhu, 2020; Sajadi et al., 2020).

Several studies have suggested that a higher temperature could be effective against different types of coronavirus such as SARS (Van Doremalen et al., 2013; Chan et al., 2011; Bi et al., 2007). In the study by Ma et al. (2020), it has been reported that there is a negative relationship between COVID-19 mortality and temperature (Ma et al., 2020) because at lower temperatures, the performance of the immune system, as well as the liver, is decreased; as a result, the situation will be conducive to the activity of infectious agents and virus transmission

(Shephard and Shek, 1998; Donaldson et al., 1999; Steel et al., 2011; Li et al., 2019; Davis et al., 2016). Furthermore, the mortality rate and incidence of COVID-19 could be associated with air pollution and the average age of the population. It seems that older populations in the northern hemisphere, especially in Europe and North America with a higher income, have a higher death rate from respiratory infections (Michel, 2010; Cristea et al., 2020; Knickman and Snell, 2002; Eurostat, 2019). Additionally, it seems that air pollution plays a determinative role in COVID-19 outbreak and mortality. For instance, day-by-day changes of pollutant concentration were positively linked with the number of infected individuals in Italy; likewise, the number of confirmed cases was extremely higher in cities with more than 100 days of air pollution than cities with cleaner air (Coccia, 2020). A substantial relationship has also been found between urban air pollution and the transmission dynamics of COVID-19. In addition, it has been established that air pollutants emitted from vehicles and industries, such as nitrogen oxide and particle matter, may affect viral infection emission and increase the number of hospital admissions due to respiratory virus bronchiolitis and asthma (Carugno et al., 2018; Glencross et al., 2020; Groulx et al., 2018; Nenna et al., 2017).

While it is still not well established in the case of the coronavirus disease, vitamin D deficiency in people living in high-latitude areas and colder climates may somehow trigger the disease in those regions (Grant et al., 2020; Zhou et al., 2005; Barger-Lux and Heaney, 2002). Vitamin D supplementation is highly recommended for preventing acute respiratory diseases, but the effectiveness of vitamin D for coronavirus infection is in urgent need of further investigations. The authors of this short communication acknowledge possible limitations, including the fast-changing pattern of the disease and the deficiencies linked with the source of data. Environmentally speaking, there are many factors that may affect COVID-19 distribution and mortality, including humidity, wind speed, and air pressure. Besides, government-based interactions such as compulsory quarantine, social distancing, and advertising precaution measures could bring substantial benefits to cope with COVID-19 in different areas. We should also address intrinsic limitations and the fallacy of ecological research to some extent. We believe that this study can provide researchers with a deeper understanding of the coronavirus distribution pattern and the associated contributing factors. It is also suggested that, in the future, studies address the effect of public awareness, social distancing, quarantine effectiveness, and people's participation in isolation plans.

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Declarations

The authors have disclosed that they do not have any conflicts of interest.

Availability of data and materials

All data and materials used in this study were publicly available and mention in the text.

Consent for publication

Not applicable.

Credit author statement

Mohammad Sarmadi: Writing - original draft, Methodology, Software,Writing- Reviewing and Editing Nilufar Marufi.: Investigation, Writing- Original draft preparation, Software Vahid Kazemi Moghadam: Conceptualization, Supervision, Writing- Reviewing and Editing

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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