Turk J Public Health
Available online at: http://dergipark.org.tr/tjph/
Doi: 10.20518/tjph.1357153

TURKISH JOURNAL OF PUBLIC HEALTH

ORIGINAL ARTICLE

The evaluation of the correlation between some variables of the countries and COVID-19 incidence of cases and deaths in different variant periods

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Received: 08.09.2023, **Accepted:** 16.02.2024

Abstract

Objective: The aim of this study is to evaluate the correlation between the incidence case/death rate of coronavirus disease 2019 (COVID-19) and some variables of the countries.

Methods: This research is an Ecological study. We analyzed the association of COVID-19 incidence of cases/deaths with population rates over 65, Gini index, GDP per capita (current US$), burden of disease (DALYs-2019), literacy rate of over 15 years old, Coefficient of Variation (CV) of caloric intake, prevalence of obesity among adults, total COVID-19 vaccine doses administered per 100 people, and total tests conducted (per 1M). Furthermore, we analyzed the data on COVID-19 incidence of cases/death in the cross-sectionally for three periods: Alpha-Beta-Gamma, Delta and Omicron periods. Spearman correlation test was used for statistical analysis.

Results: Positive correlations were found in COVID-19 cumulative incidence of cases/deaths (per 1M), and population rates over 65, GDP (per capita), lliteracy rate of individuals over 15 years old, prevalence of obesity among adults, and total COVID-19 vaccine doses administered per 100 people. On the other hand, negative correlations were found with DALYs, Coefficient of Variation (CV) of caloric intake and Gini index. When the variant periods of COVID-19 were examined respectively (Alpha-Beta-Gamma, Delta and Omicron), the positive correlations and the negative correlations were further increased during the Omicron period.

Conclusion: It is recommended to consider the demographic and socioeconomic characteristics of the countries, as well as the characteristics of the disease agent, for the prevention and control of potential future pandemics.

Keywords: COVID-19, DALYs, Aged, Obesity, Correlation Study

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Cite This Article: Erdal D., Uguz BE, Sasmaz CT. The evaluation of the correlation between some variables of the countries and COVID-19 incidence of cases and deaths in different variant periods. Turk J Public Health 2024;22(1): 49-58.

INTRODUCTION

The coronavirus disease 2019 (COVID-19), which was declared as a pandemic by World Health Organization (WHO) in March 2020, still continues. As of March 01, 2023, over 758 million confirmed cases and over 6.8 million deaths have been reported globally.[1]

Risk factors associated with COVID-19 cases and deaths have been identified in the pandemic. Advanced age, presence of chronic disease, obesity and pregnancy are the main risk factors. Approximately 81% of deaths from COVID-19 occurred in people over 65 years old.[2] In a study evaluating data from 16 countries; It has been determined that the mortality rate of COVID-19 is 62 times higher in those aged 65 and over. In the same study, the mortality rate from COVID-19 was found to be 77% higher in men than in women. [3] Obesity has been reported to increase the risk of both COVID-19-related hospitalizations and death.[4]

İncome level has a marked influence on health. According to studies, income inequality has been associated with declining population health.[5,6]. In a study, it was found that there was a positive correlation between the pandemic's mortality burden and national income per capita. For example, it has been determined that Brazil's mortality burden (adjusted by population) is 1000 times greater than Thailand's, despite enormous differences at each income level.[7]

Differences in COVID-19 cases, deaths and incidence among countries may also result from case and death reporting. According to officially reported deaths, while 98% of deaths are due to COVID-19 in the European region, it has decreased to 10% in the African region.[8]

Although the differences in incidence case and death rate among countries are known during the pandemic process, it is seen that the factors associated with this difference among countries have not been sufficiently investigated in the literature. The aim of this study is to investigate the relationship between the incidence case and death rate of COVID-19 and several fundamental variables of the countries.

METHODS

This research was planned as an Ecological study. The research was conducted between January and April 2023. Ethics committee approval was not obtained as this research was conducted with open data.

Research Data

In this study, data from 207 world countries included COVID-19 cumulative incidence of cases and deaths, population rates over 65, Gini index, GDP per capita (current US$), burden of disease (DALYs-2019), Literacy rate of over 15 years old, Coefficient of Variation (CV) of caloric intake, prevalence of obesity among adults, total COVID-19 vaccine doses administered per 100 people, total test (per 1M). Data from some countries were not available. Therefore, the available data were analyzed.

Population rates over 65 and GDP per capita (current US$) for 2021 were obtained from The World Bank. The 15+ literacy rate and Gini index data were also provided by the World Bank, but since the most recent years of data differ from country to country, the countries whose data are available after 2010 were included.[9] Coefficient of Variation (CV) of caloric intake, prevalence of obesity

among adults, total COVID-19 vaccine doses administered per 100 people, COVID-19 cumulative incidence of cases and deaths, Burden of disease (DALYs-2019) were obtained from Our World in Data.[10] Total test (per 1M) were obtained from Worldometers.[11]

We analyzed the data on COVID-19 incidence of cases/death in the cross-sectionally for three periods: the first period is Alpha-Beta-Gamma, the second period is Delta and the third period is Omicron. The first period was taken from January 04, 2020 to May 10, 2021.The beginning of the second period was chosen as the day on which WHO Variants of Concern (VOC) for the delta period declared (May 11, 2021). The second period was taken from May 10, 2021 to Nov 25, 2021. For the Omicron period, the same procedure was applied. (Nov 26, 2021).[12] The last data was taken on January 16, 2023. The third period was taken from Nov 25, 2021 to Jan 16, 2023.

Disability Adjusted Life Years (DALYs)

The sum of mortality and morbidity is referred to as the 'burden of disease' and it can be measured 'Disability Adjusted Life Years' (DALYs). They measure lost health and are used to measure disease burdens. It can be seen that rates in areas with the best health are less than 20,000 DALYs per 100,000 people. This is achieved in many European countries and in some countries (Canada, Israel, South Korea, Taiwan, Japan et.).[13]

Gini Coefficient and GDP (Per Capita)

Gini coefficient and GDP (per capita) are some metrics used for income measurements. The income distribution of a population is measured by the Gini coefficient. Lower values indicate a lower level of inequality. The Gini Index which is provided by The World Bank, has a range of 0 to 100, with 0 denoting no income inequality and 100 denoting the greatest level of income equality.[14,15]

Obesity

The prevalence of obesity is seen in high-income countries across Europe, North America, and Oceania. In South Asia and Sub-Saharan Africa, obesity rates are significantly lower.[16]

Coefficient of Variation (CV) of Caloric Intake

The Food and Agriculture Organization of the United Nations uses "undernourishment" as its primary indicator to assess the availability of food and nutrition. The coefficient variation (CV) calculates the inequity in calorie intake among a population. It is a statistical measurement of the range of data around the mean caloric intake. Higher CV values represent larger levels of dietary inequality. The countries with the highest levels of dietary inequality typically are Sub-Saharan Africa (particularly Zambia, Cote d'Ivoire, and Burkina Faso), Iraq, and Haiti.[17,18]

Statistical Analysis

The analyzes of the data were done via computer. Descriptive statistics such as mean, standard deviation, median, minimum and maximum value were used to summarize the data. The data were tested for normality using Kolmogorov–Smirnov tests. The data were not normally distributed, so Spearman correlation analysis was done. $p < 0.05$ was considered significant.

RESULTS

Positive correlations were found in COVID-19 cumulative incidence of cases/deaths (per 1M), and Population rates over 65, GDP (per capita), Literacy rate of over 15 years old,

prevalence of obesity among adults, total COVID-19 vaccine doses administered per 100 people. On the other hand, negative correlation was found with DALYs, Coefficient of Variation (CV) of caloric intake and Gini index (Table 1).

Table 1. Correlation between COVID-19 cumulative incidence of cases/deaths and some variables

Variables	Median (min-max)	COVID-19 cumulative incidence of cases (per 1M)	COVID-19 cumulative incidence of death (per 1M)
COVID-19 Total Test (per 1M)	765559.5 (5091- 22620639)	+0.881*	+0.647*
GDP per capita (current US$) (n=204)	6930.1 (221.5-234315.5)	+0.850*	+0.649*
Literacy rate of over 15 years old (n=153)	94 (27- 100)	+0.755*	+0.648*
Population rates over 65 (n=207)	8 (1-36)	+0.773*	+0.768*
Prevalence of obesity among adults (n=186)	12.7 (0.5- 53.1)	+0.634*	+0.592*
Total COVID-19 vaccine doses administered per 100 people (n=200)	147.18 (0.22-406.43)	+0.622*	+0.370*
Burden of disease (DALYs-2019) (rates per 100,000) (n=189)	29732.69 (15045.11- 90772.64)	-0.761*	-0.671*
Coefficient of Variation (CV) of caloric intake (n=181)	0.25 (0.17- 0.41)	-0.717*	-0.580*
Gini index (n=154)	35.8 (23.2-63.0)	-0.378*	-0.224**

* p<0.001, **p<0.01

When the variant periods of COVID-19 were examined respectively (the first period: Alfa, Beta, Gama; the second period: Delta; the third period: Omicron), the positive correlation were between the incidence of cases/deaths and the population rates over 65, GDP (per capita), literacy rate of over 15 years old, and obesity prevalence in adults further increased during the omicron period. Likewise, the negative correlation between the incidence of cases/deaths and Gini index, DALYs, Coefficient of Variation (CV) of caloric intake further increased during the omicron period (Table 2- 3, Figure 1-2).

Table 2. Correlation between COVID-19 incidence of cases and some variables according to variant periods of COVID-19

Variables	COVID-19 incidence of cases (per 1M) (Alfa, Beta, Gama) (n=197)	COVID-19 incidence of cases (per 1M) (Delta) (n=200)	COVID-19 incidence of cases (per 1M) (Omicron) (n=203)
GDP per capita (current US$) (n=204)	+0.588*	+0.612*	+0.828*
Literacy rate of over 15 years old (n=153)	+0.562*	+0.614*	+0.700*
Population rates over 65 years old (n=207)	+0.583*	+0.581*	+0.741*
Prevalence of obesity among adults (n=186)	+0.585*	+0.407*	+0.618*
Burden of disease (DALYs-2019) (rates per 100,000) (n=189)	-0.652*	-0.618*	-0.710*
Coefficient of Variation (CV) of caloric intake (n=181)	-0.538*	-0.491*	-0.701*
Gini index (n=154)	-0.323*	-0.231**	-0.351*

* p<0.001, **p<0.01

Table 3. Correlation between COVID-19 incidence of deaths and some variables according to variant periods of COVID-19

Variables	COVID-19 incidence of death (1M) (First period: Alfa, Beta, Gama) (n=188)	COVID-19 incidence of deaths (1M) (Second period: Delta) (n=191)	COVID-19 incidence of deaths (1M) (Third period: Omicron) (n=200)
GDP per capita (current US$) (n=204)	+0.559*	+0.334*	+0.739*
Literacy rate of over 15 years old (n=153)	+0.572*	+0.574*	+0.676*
Population rates over 65 years old (n=207)	+0.635*	+0.434*	+0.843*
Prevalence of obesity among adults (n=186)	+0.684*	+0.436*	+0.617*
Burden of disease (DALYs-2019) (rates per 100,000) (n=189)	-0.588*	-0.363*	-0.692*
Coefficient of Variation (CV) of caloric intake (n=181)	-0.506*	-0.298*	-0.692*
Gini index (n=154)	-0.204***	-0.017****	-0.343**

* p<0.001, **p<0.01, ***p<0.05, ****p>0,05

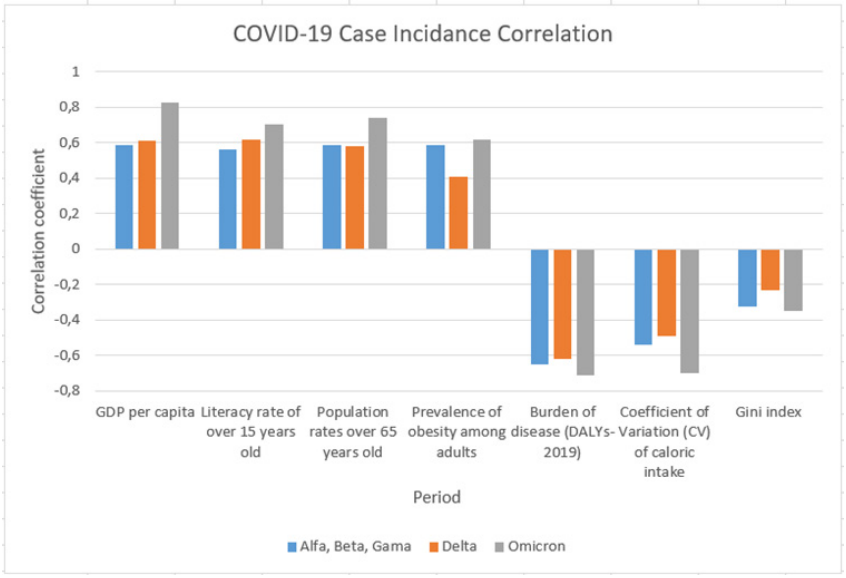

Figure 1. The change of the correlation value between the case incidence and the variables in three different periods during the COVID-19 pandemic process

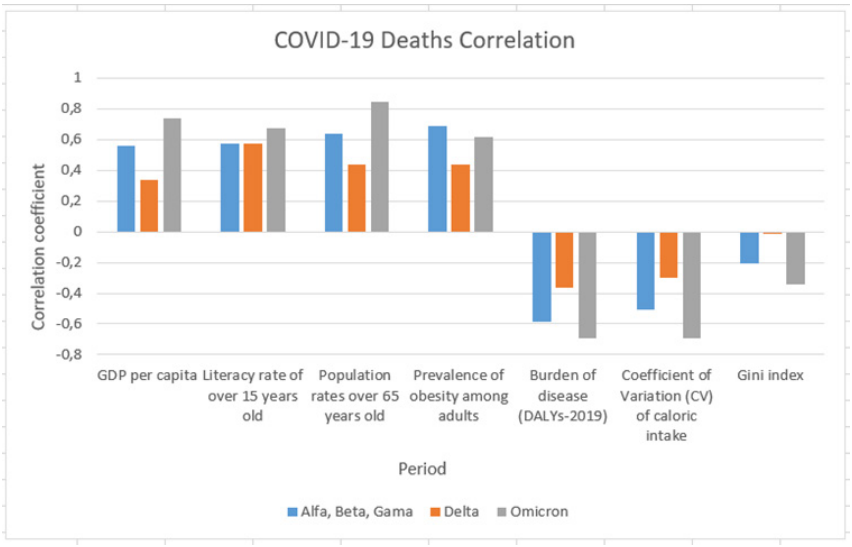

Figure 2. The change of the correlation value between the variables and the deaths in three different periods during the COVID-19 pandemic process

DISCUSSION

The Human Development Index (HDI) is measured by life expectancy, access to education and GDP (per capita). There are significant regional variations, ranging from the lowest in central Africa to the highest values in North America, Europe, Japan, and Oceania.[19] Countries with older populations and high obesity prevalence is high-income countries. High-income countries have aging populations and a high prevalence of obesity.[16,20] There were also differences between countries in testing capacity and vaccine access (testing capacity and vaccine coverage are higher in high-income countries).[21] In addition, variables like DALYs, the Gini index, and the coefficient of variation of calorie intake differ between high- and low-income countries.[13,15,18] Although DALYs have lower values in high-income countries, the prevalence of cardiovascular disease and obesity is higher in these countries than in

low-income countries.[22] Our study results show that the elderly population, literacy rate, per capita income, obesity prevalence, and the increase in the number of administered COVID-19 vaccine doses are similarly related to increasing the incidence and mortality of COVID-19. On the other hand, DALYs, change in caloric intake, and increase in Gini coefficient are also related to decreasing the incidence and mortality of COVID-19. It is thought that the socioeconomic status of the countries is the determining factor behind the variables clustered in these two groups. The high socioeconomic status both increases the testing capacity and the probability of detecting cases, and also causes an increase in the risky groups defined for COVID-19 cases and mortality (obesity, elderly population ratio). These results show that the socioeconomic level of the countries is a confounding factor in case incidence and mortality in the COVID-19 pandemic.

Some studies in countries and meta-analyses, the incidence of COVID-19 cases and deaths has been linked to low socioeconomic status.[23,24] However, in our study it was found that as GDP per capita increased, the incidence of COVID-19 cases/deaths also increased. To explain this contradictory situation, we examined the African region. At the outset of the pandemic, the weak public health infrastructure raised concerns that the African continent would suffer negative effects. In the days that followed, there were fewer cases and deaths reported. But the infection estimates in the region are approximately 100 times higher than infection reports. According to several serosurveys, large waves of infection hit Africa, but most cases went unreported because they rarely resulted in serious illness. According to a serosurvey conducted in Zambia, there was only one reported case for every 92 infections that actually occurred. [25] According to evidence from Kenya, Malawi, and the Democratic Republic of the Congo, up to 80% of the population may have been infected by COVID-19 before the omicron variant arrived.[26–28] Although limited testing capacity is a contributing factor, Africa's demography also plays a significant role in the underreporting of cases because of its young population, which results in a high percentage of mild and asymptomatic cases.[29] Because the risk of serious illness and death from COVID-19 increases with age. Even estimates of the total COVID-19 deaths in the African region, which are up to ten times higher than the reported figures, it is the continent with the second-lowest death rate per million inhabitants.[21] The low COVID-19 incidence of cases/deaths in low-income countries may be related to the low test-diagnosis capacity in these countries, as well as the low rate of the elderly population and obesity prevalence.

In a study examining data from 176 countries, they found linear correlations between COVID-19 morbidity/ mortality (per 1M) and GDP (per capita) and overweight/ obesity prevalence (% of population).[8] A study found a negative correlation (−0,665/ p=0.001) between GDP (per capita) and the number of new COVID-19 cases (per 1M). There was no evidence of a statistically significant correlations between obesity and the new cases of COVID-19 (per 1M).[30] The reason for this difference is that this research was conducted only in 38 European countries and in the early months of the Pandemic. An analysis focused on Africa explored factors with potential impacts on the risk of COVID-19 infection and mortality rate. COVID-19 tests per 1 million populations, GINI index and BMI

were significantly associated with the increase in COVID-19 cases per 1 million population in Africa. Furthermore, the prevalence of diabetic patients was significantly associated with the increase in the COVID-19 deaths per 1 million populations in Africa.[31] The highest GDP per capita of the Latin American countries analyzed is that of Panama which was found the highest incidence of cases (per 1M). The lowest GDP per capita of these countries is Haiti that was the lowest incidence of cases (per 1M).[32] Obesity has been observed in other studies as a risk factor for COVID-19-related deaths.[4] According to a study done at the outset of the pandemic, globally, non-communicable disease DALYs were correlated with COVID-19 cases and deaths.[33] In the literature, it is reported that COVID-19 incidence of cases/deaths increases with the increase in income level, except for a study conducted at the outset of the pandemic in high-income countries. It is seen that the increase in obesity and chronic diseases is similarly related to the COVID-19 incidence of cases/deaths.

Although the gradual reduction of inequality in vaccine distribution, high-income countries administer 69 times more vaccine doses per population than low-income countries.[34] High-income countries have vaccinated 75-80% of their populations on the other hand low-income countries have vaccinated <10% of their populations by the end of 2021.[35] A study including 191 countries found a positive correlation between vaccination rate and bi-weekly incidence rate and a weak negative correlation between vaccination rate and case fatality rate.[36] Although the disease prevention effect of COVID-19 vaccines against variants has decreased, it is not enough to explain the positive correlation between COVID-19 incidence of cases/death (per 1M) and total COVID-19 vaccine doses administered per 100 people.[37] This paradox can be explained by the average age of the population, the comorbidity index of the population, herd immunity. [38]

According to a meta-analysis of 39 studies, the fatality rate for COVID-19 was 3% in those under 50, it was 19% in those over 50. [39]According to a study using compiled age-specific death data from 9 countries, the risk of COVID-19 mortality is significantly higher for the old people than for the younger ones. About 70% of COVID-19 deaths in the USA occur in people aged 70 or older.[40] Likewise in our research, we found the COVID-19 incidence of cases/deaths higher in countries with a high population over 65. İn COVID-19 pandemic, age became one of the most important factors in the incidence and mortality of the disease. In our study, the positive correlation between the population aged 65 and over and the incidence and mortality of the disease supports this relationship.

Our study is unique in the literature, the correlational relationship was analyzed by dividing the COVID-19 pandemic process into three separate periods according to the variants unlike other studies. It was found that the correlational relationship obtained with the independent variables was similar in three different periods, but the correlation coefficients (more pronounced in case incidence) were higher in the omicron variant period. This can be explained by the fact that the dominant omicron variant in the last period of the pandemic was more contagious and the vaccines used had lower protection against this variant.

CONCLUSION

As a result, there is a positive correlation between COVID-19 incidence of cases/death and population rates over 65 years old, GDP per capita, literacy rate over 15 years old, prevalence of obesity among adults, COVID-19 Total Test (per 1M) and total COVID-19 vaccine doses administered per 100 people; there is a negative correlation between COVID-19 incidence of cases/death and the Gini index, DALYs and Coefficient of Variation (CV) of caloric intake. The level of correlation is higher in the Omicron variant period than in other periods. This scientific evidence detected in the COVID-19 pandemic will be a guide for pandemics in the future. To prevent a possible pandemic in the future, it is recommended to consider the demographic and socioeconomic characteristics of the countries as well as the characteristics of the disease agent.

ACKNOWLEDGEMENT

Thanks to Sevim Yılmaz for translation support.

Concflict of Interest: No conflict of interest.

Financial Support: No funding support.

Ethical Declaration: Ethics committee approval was not obtained as this eco-logical type research was conducted with open data.

Authorship Contrubitions: Concept: DE, CTS, BEU, Design: DE, CTS, BEU, Supervising: DE, CTS, BEU, Data collection and entry: DE, Analysis and interpretation: DE, CTS, Literature search: DE, CTS, BEU, Writing: DE, CTS, BEU, Critical review: DE, CTS, BEU.

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