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Investigation of Factors Associated with Countries' Covid-19 Disease Fatality Rates

Ülkelerin Covid-19 Hastalığı Fatalite Hızlarıyla İlişkili Faktörlerin Araştırılması

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Abstract

Aim In this study, it was aimed to investigate the factors associated with the Covid-19 disease fatality rate of countries.

Material and Method The research is of ecological type. In the study, the relationship between Covid-19 disease fatality rates and variables like socioeconomic state, healthy life expectancy at birth, population ages 65 and above, cardiovascular disease frequency, tobacco use frequency, vaccination rates, Human Development Index, Gender Inequality Index and Global Gender Gap Index were investigated. Mean, standard deviation, median, minimum and maximum values were used to summarize data. Pearson/Spearman correlation coefficient was used to investigate the relationships and a linear regression model was established. $P < 0.05$ was considered statistically significant.

Results One hundred and thirty countries with no missing data were included in the study. Twelve point three percent of these countries were in low socioeconomic state. The mean fatality rate of 130 countries was 0.016 ± 0.018 . A statistically significant relationship was determined between fatality rate and all variables except tobacco use frequency ($p < 0.05$). All the variables were included in the multiple linear regression model established for the prediction of the fatality rate. Among these variables, Global Gender Gap Index was the only variable that made a statistically significant contribution to the model.

Conclusion Considering these variables in similar epidemic disease states that may occur in the future and improving the conditions related to these variables on a global scale may be important to ensure epidemic control.

Keywords Covid-19 pandemic, fatality rate, related factors, ecological study

Özet

Amaç Bu çalışmada ülkelerin Covid-19 hastalığı fatalite hızıyla ilişkili faktörlerin araştırılması amaçlanmıştır.

Gereç ve Yöntem Araştırma ekolojik tiptedir. Araştırmada Covid-19 hastalığı fatalite hızlarıyla sosyoekonomik durum, doğumda beklenen sağlıklı yaşam umudu, 65 yaş ve üzeri nüfus yüzdesi, kardiyovasküler hastalık sıklığı, bütün kullanım sıklığı, İnsani Gelişmişlik İndeksi, Toplumsal Cinsiyet Eşitsizliği İndeksi ve Küresel Cinsiyet Uçurumu İndeksi gibi değişkenlerin ilişkisi araştırılmıştır. Verilerin özetlenmesinde ortalama, standart sapma, ortanca, minimum ve maksimum değerleri kullanılmıştır. Veriler arası ilişkilerin araştırılmasında Pearson/Spearman korelasyon katsayısı kullanılmış ve lineer regresyon modeli kurulmuştur. $P < 0,05$ istatistiksel olarak anlamlı kabul edilmiştir.

Bulgular Verilerinde eksiklik bulunmayan 130 ülke çalışmaya dahil edildi. Ülkelerin %12,3'ü düşük sosyoekonomik sınıftaydı. Yüz otuz ülkenin ortalama fatalite hızı 0.016 ± 0.018 idi. Fatalite hızıyla bütün kullanım sıklığı hariç tüm değişkenler arasında istatistiksel olarak anlamlı ilişki belirlendi ($p < 0.05$). Tüm değişkenler, fatalite hızının tahmini için oluşturulan çoklu doğrusal regresyon modeline dahil edildi. Modele istatistiksel olarak anlamlı katkı sağlayan tek değişken Küresel Cinsiyet Uçurumu İndeksi oldu.

Sonuç Gelecekte ortaya çıkabilecek benzer salgın durumlarında bu değişkenlerin dikkate alınması ve bu değişkenlerle ilişkili koşulların küresel ölçekte iyileştirilmesi salgın kontrolünün sağlanması açısından önemli olabilir.

Anahtar Kelimeler Covid-19 pandemisi, fatalite hızı, ilişkili faktörler, ekolojik çalışma.

INTRODUCTION

Covid-19, which seriously threatens public health and progresses as a pandemic, is a viral disease identified in late 2019. The disease, the first case of which was observed in Turkey on March 11, 2020, can be asymptomatic or mild, or it can have a severe course that requires hospitalization and intensive care unit admission and leads to death¹. There are various vaccines that are thought to be effective in protecting against Covid-19². In addition, personal protective behaviors such as frequent hand washing/disinfectant use, not touching the face with hands, wearing masks appropriately, complying with social distance, not leaving the house unless necessary, keeping surfaces/items clean also seem to be important for breaking the way of transmission of Covid-19³. These personal protective behaviors are also called non-drug public health measures and are thought to play a key role in preventing the spread of Covid-19 disease in the community⁴.

Social determinants of health are shown as factors that may affect the transmission of the Covid-19 disease and/or the severity of the disease. These factors include socioeconomic status, race/ethnicity, working status, housing conditions, education level, nutritional status, immigration, gender inequality, cultural factors, social policies, and the state of the health system⁵. In a systematic review that investigated the factors affecting the incidence rate of Covid-19 disease and included 42 studies, socioeconomic status, housing conditions, nutritional status, education level, race, and working status were determined as effective factors⁶. It is thought many factors can affect that fatality rate of Covid-19 disease, such as demographic factors, health infrastructure, access to public health services, ethnicity, economic conditions, environmental factors, and chronic disease frequency⁷⁻⁹.

In this study, it was aimed to investigate the factors associated with the Covid-19 disease fatality rate of countries.

MATERIALS and METHODS

The research is of ecological type. Ethics committee approval was got from Ankara University's Rectorate Ethics Committee and approval from the Ministry of Health Scientific Research Platform in order to conduct the research. The research was conducted between 15.11.2021 and 15.04.2022. In the study, the relationship between Covid-19 disease fatality rates and socioeconomic state, physicians per ten thousand people, healthy life expectancy at birth, deaths among 30-70 years because of non-communicable diseases, population ages 65 and above (% of total population), diabetes mellitus (DM) frequency, cancer frequency, cardiovascular disease (CVD) frequency, chronic lung disease (CLD) frequency, tobacco use frequency, health expenditure as a percentage of gross domestic product (GDP), vaccination rates, Human Development Index (HDI), Gender Inequality Index (GII) and Global Gender Gap Index (GGGI) variables were investigated.

From the data of the study, the variables of the number of cases and deaths of Covid-19 disease and the number of physicians per ten thousand people were got online from WHO^{10,11}, countries' socioeconomic state and population ages 65 and above (% of total population) from the World Bank^{12,13}, healthy life expectancy at birth, and death among 30-70 years because of non-communicable diseases from WHO Health Statistics 2021¹⁴, DM, CVD, cancer and CLD frequencies from Global Burden of Disease Study 2019¹⁵, tobacco use frequency from WHO Report on Tobacco Use Prevalence Trends¹⁶, health expenditure as a percentage of GDP from Global Burden of Disease Study Health Financing working group¹⁷, countries' vaccination rates from Our World in Data¹⁸, HDI and GII from United Nations^{19,20}, GGGI from the World Economic Forum²¹. In data selections, the most recent ones were selected and used.

Statistical Analysis

Data entry, analysis, and report writing were carried out in the computer environment. Countries with no missing data were included in the analysis. The mean, standard

deviation, minimum and maximum values were used to summarize the data. Pearson/Spearman correlation coefficient (r) was used to investigate the relationships between variables. In the evaluation of the calculated coefficients, 0.90-1.00 very strong relationship, 0.70-0.89 strong relationship, 0.40-0.69 moderate relationship, 0.20-0.39 weak relationship and 0.00-0.19 was interpreted as a negligible relationship. Negative correlation coefficients show that the variable decreases while the other increases or, on the contrary, positive correlation coefficients show that the variables decrease and increase together²². Linear regression analysis was performed and scatter plots were drawn to determine the variables associated with Covid-19 disease fatality rates. $P < 0.05$ was considered statistically significant.

RESULTS

One hundred and thirty countries with no missing data were included in the study. Twelve point three percent of these countries were in low ($n=16$), 25.4% in lower middle ($n=33$), 26.2% in upper middle ($n=34$) and 36.2% in high ($n=47$) socioeconomic state (Figure 1).

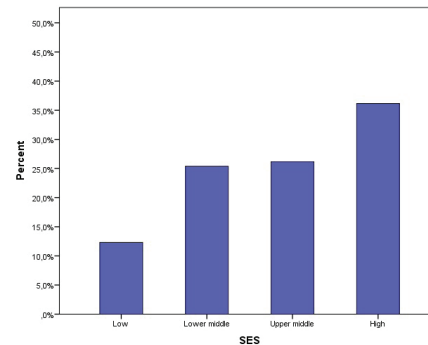


Figure 1. Countries' Socioeconomic States

The mean fatality rate of 130 countries was 0.016 ± 0.018 . The mean number of physicians per ten thousand people was $22,071 \pm 18,225$. The characteristics of the variables of the countries included in the study are presented in Table 1.

A statistically significant relationship was determined between fatality rate and all variables except tobacco use frequency ($p < 0.05$). The correlation coefficients and p values calculated between the fatality rate and the research variables are presented in Table 2.

Variables	Mean	Standard Deviation	Median	Minimum	Maximum
Fatality rate	0,016	0,018	0,012	0,000	0,182
Physicians per ten thousand people	22,071	18,225	22,100	0,350	84,200
Healthy life expectancy at birth (year)	64,192	6,254	65,800	44,200	74,100
Death among 30-70 years because of non-communicable diseases (%)	18,555	7,403	18,500	7,300	42,700
Population ages 65 and above (%)	10,253	6,984	7,825	1,264	28,397
DM frequency (%)	0,067	0,036	0,067	0,011	0,164
CVD frequency (%)	0,076	0,037	0,064	0,029	0,165
Cancer frequency (%)	0,015	0,014	0,008	0,001	0,066
CLD frequency (%)	0,068	0,032	0,056	0,029	0,161
Tobacco use frequency (%)	0,337	0,210	0,326	0,025	0,880
Health expenditure as a percentage of GDP (\$)	1358,869	2091,691	423,000	22,000	11345,000
Vaccination rate (%)	129,789	77,857	138,372	0,105	312,384
HDI	0,745	0,154	0,779	0,394	0,957
GII	0,337	0,210	0,326	0,025	0,880
GGGI	0,708	0,066	0,712	0,492	0,892

		Fatality Rates					P
		Mean	Standard Deviation	Median	Minimum	Maximum	
WHO regions	Europe	0,010	0,008	0,008	0,001	0,042	<0.001
	Americas	0,020	0,015	0,016	0,006	0,060	
	Africa	0,019	0,009	0,019	0,000	0,040	
	South East Asia	0,017	0,010	0,014	0,006	0,032	
	Western Pasific	0,006	0,007	0,003	0,001	0,022	
	Eastern Mediterranean	0,026	0,046	0,011	0,002	0,182	
Socioeconomic state	Low	0,031	0,041	0,022	0,000	0,182	<0.001
	Lower middle	0,018	0,010	0,017	0,001	0,048	
	Upper middle	0,018	0,013	0,013	0,005	0,060	
	High	0,007	0,006	0,006	0,001	0,024	

The relationships of the variables with the fatality rate were analyzed with scatter plots and presented in Figure 2.

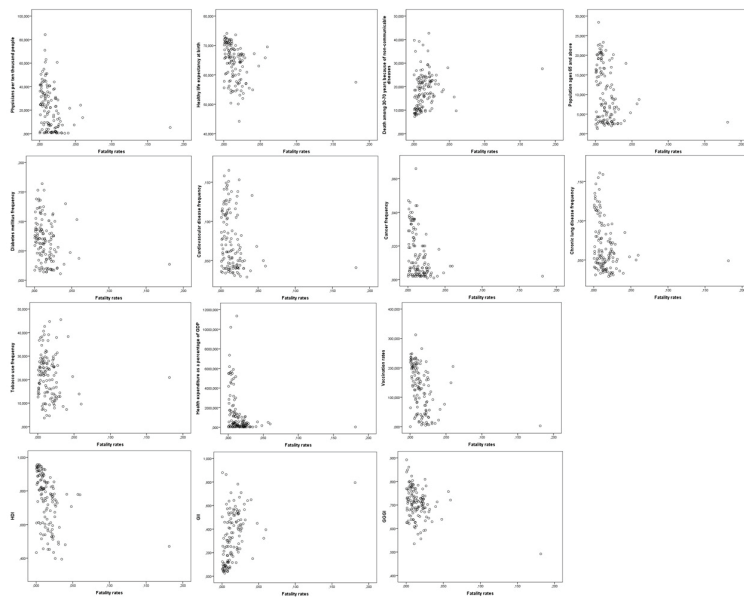


Figure 2. Scatterplots of the Relationships of Research Variables with Fatality Rate

All the variables were included in the multiple linear regression model established for the prediction of the fatality rate. Among these variables, GGGI was the only variable that made a statistically significant contribution to the model. The model is presented in Table 3.

All the variables were included in the multiple linear regression model established for the prediction of the fatality rate. The WHO region variable, which is not an ordinal or numerical variable, was included in the analysis as a dummy variable, considering the Western Pacific region with

the lowest fatality rate. Among these variables, GGGI was the only variable that made a statistically significant contribution to the model. The model is presented in Table 4.

Table 3. Investigation of Correlation Between Fatality Rate and Research Variables		
Variables	Correlation Coefficients	P
Socioeconomic state	-0,546	0,001*
Physicians per ten thousand people	-0,439	0,001*
Healthy life expectancy at birth (year)	-0,437	0,001*
Death among 30-70 years because of non-communicable diseases (%)	0,337	0,001*
Population ages 65 and above (%)	-0,317	0,001*
DM frequency (%)	-0,316	0,001*
CVD frequency (%)	-0,298	0,001*
Cancer frequency (%)	-0,444	0,001*
CLD frequency (%)	-0,343	0,001*
Tobacco use frequency (%)	-0,162	0,065
Health expenditure as a percentage of GDP (\$)	-0,499	0,001*
Vaccination rate (%)	-0,544	0,001*
HDI	-0,568	0,001*
GII	0,523	0,001*
GGGI	-0,296	0,001*
*It shows values with P<0.05.		

Table 4. Linear Regression Model for Prediction of Fatality Rate			
Variables	Standardized Coefficients	t	P
Socioeconomic state	-0,277	-1,162	0,248
WHO region (Western Pasific/Others)	-0,101	-1,013	0,313
Physicians per ten thousand people	0,023	0,138	0,890
Healthy life expectancy at birth (year)	0,104	0,481	0,632
Death among 30-70 years because of non-communicable diseases (%)	0,046	0,265	0,791
Population ages 65 and above (%)	0,312	0,989	0,325
DM frequency (%)	0,030	0,229	0,819
CVD frequency (%)	-0,148	-0,471	0,639
Cancer frequency (%)	-0,065	-0,231	0,818
CLD frequency (%)	0,133	0,702	0,484
Tobacco use frequency (%)	-0,015	-0,153	0,879
Health expenditure as a percentage of GDP (\$)	-0,059	-0,360	0,720
Vaccination rate (%)	-0,201	-1,117	0,266
HDI	0,125	0,374	0,709
GII	0,186	0,821	0,413
GGGI	-0,270	-2,461	0,015
B=0.044 R=0.501 R²=0.251 F=2.367 p=0,004			

DISCUSSION

In our study, socioeconomic state, physicians per ten thousand people, healthy life expectancy at birth, death among 30-70 years because of non-communicable diseases, population ages 65 and above (% of total population), DM frequency, CVD frequency, cancer frequency, CLD frequency, tobacco use frequency, health expenditure as a percentage of GDP, vaccination rates, HDI, GII and GGGI were determined as variables related to the Covid-19 fatality rate. In the established regression model, GGGI variable is the only variable with a significant p value among the variables that contribute to the model. In the study conducted by Coccia in which 160 countries were evaluated, gross domestic product (GDP) per capita, high health expenditures and air pollution were associated with fatality⁸. Jain et al. investigated the factors affecting Covid-19 mortality in India and western countries. In the study, variables such as the elderly population, diseases affecting the immune system, including genetics, mutant types of the virus, temperature and humidity, long-term quarantine practices, BCG vaccine, recurrent respiratory system infections, obesity, race and ethnicity were discussed as possible factors²³. In the study of Upadhyay and Shukla, the factors affecting the Covid-19 fatality rate in the states of India were investigated and a positive correlation was determined with life expectancy, prevalence of overweight, Covid-19 test positivity rates and death rates from H1N1²⁴. In a systematic review of 114 studies by Mehraeen et al., advanced age, hypertension, and DM were found to be associated variables²⁵. In a meta-analysis by Sepandi et al., in which 13 studies were evaluated, advanced age, male gender, DM, hypertension, kidney diseases, respiratory system diseases and heart diseases were found to be associated with Covid-19 mortality²⁶. de Oliveira et al., in their study at the beginning of the pandemic, associated the variables of GDP per capita, health expenditure as a percentage of GDP, infant mortality rate, physicians per thousand people, urban population ratio, number of people per km² with mortality and fatality rates⁹. Upadhyaya et al. found obesity, population ages 65 and above (% of

total population), urbanization, and GDP per capita to be associated with Covid-19 mortality²⁷. In the literature, the variables associated with Covid-19 mortality and fatality in studies related to the subject are Goh et al. population over 65 years of age and DM²⁸, Pan et al., number of tomography per million population and prevalence of tobacco use²⁹, number of tests by Velasco et al., advanced age, rural population, air temperature, population density³⁰, Sorci et al. population over 70 years of age, GDP per capita, level of democracy, the number of hospital beds per thousand people, DALY due to CVS, cancer and chronic respiratory diseases, smoking-related death rate and lower respiratory tract infection in people over 70 years old³¹, population density of Sornette et al., elderly population ratio and frequency of quarantine measures³², Hasan et al. population over 65, population density, number of Covid-19 tests, GDP per capita, Yesterday either-wide management indicators (an index) and obesity prevalence³³, Banik et al. access to public health services, age structure of the population, poverty level and BCG vaccination⁷, Silva and Tsigaris population over 65 years of age, international travel restrictions, public health nationality able to travel with no delays, number of tests and visas for information campaigns and testing policies³⁴.

Socioeconomic status of countries and some comorbidities were found to be factors associated with fatality rates in all the studies reviewed, including ours. This situation makes us think that many social, cultural, economic and individual factors play a role not only for non-communicable diseases but also for communicable diseases at all stages starting from transmission, and in fact, just like non-communicable diseases, there is a multifactorial aspect in communicable diseases as well. The part that should be considered and interpreted carefully is that the factors found in our study and in similar studies in the literature can be factors individually as the determinant of the fatality rate, they can be factors when they are together or their effects can be more when they are together. For this reason, it may be more appropriate to examine and evaluate these factors

together instead of examining them individually.

Highlights and Limitations of the Research

The study is important to research and trying to reveal the factors associated with an infectious disease that is as a pandemic. Because it is necessary to know the related factors in order to manage the situations related to other viral factors that may occur soon. In addition, fatality rates and all Covid-19 variants were included in the study since the beginning of the pandemic. These are the highlights of the research.

Countries with missing data were not included in the study. Since the research is of ecological type, it is necessary to be careful in the evaluation of the determined relationships in terms of causality. The relationships identified are prone to ecological fallacy, because of the type of research. These are the limitations of the research.

CONCLUSION

As a result of the research, socioeconomic state, physicians per ten thousand people, healthy life expectancy at birth, deaths among 30-70 years because of non-communicable diseases, population ages 65 and above, DM frequency, cancer frequency, CVD frequency, CLD frequency, health expenditure as a percentage of GDP, vaccination rates, HDI, GII and GGGI were determined as variables associated with the Covid-19 disease fatality rate. The only variable found statistically significant in the regression model was GGGI.

Considering these variables in similar epidemic disease states that may occur in the future and improving the conditions related to these variables on a global scale may be important to ensure epidemic control.

Conflicts of Interest

The authors have no conflicts of interest relevant to this article.

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Author Contributions

Concept – ENYÖ, MÖ, MU; Design – ENYÖ, MÖ, MU; Supervision – MU; Funding – None; Materials – ENYÖ, MÖ, MU; Data collection and/or processing – ENYÖ, MÖ; Data analysis and/or interpretation – ENYÖ, MÖ, MU; Literature search – ENYÖ, MÖ, MU; Writing – ENYÖ, MÖ, MU; Critical review – MU.

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