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Research Article

Important factors affecting the transmission rate of COVID-19 in G20 and EU

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ABSTRACT

Coronavirus 2019 (COVID-19) is an infectious respiratory disease that might be fatal to humans due to severe acute respiratory syndrome coronovirus-2. COVID-19 first appeared in Wuhan, China in 2019 and soon have spread all over the world. Therefore, it was accepted as a global epidemic by the World Health Organization in March 2020. The aim of this study is to reveal the effects of the demographic structure of the countries, their socio-economic development, the precautions, and health practices implemented by the governments against COVID-19 on the rate of transmission until the first peak days (plateaus) are appeared. Due to the socio-economic developments and reaching out the clear and transparent COVID-19 dataset, the sample of the study was formed from G20 and EU countries. The interpretable factors affecting the transmission rate of COVID-19 were extracted with factor analysis and multidimensional scaling. Multivariate analysis figures out the effects of the precautions and health practices implemented by G20 and EU countries with similar/different socio-economic development characteristics on the transmission rate. For instance, a result obtained from the multivariate analyzes is that COVID-19 cases in developed and developing countries differ from each other at their first plateaus. Another noteworthy inference is that COVID-19 cases are trending similarly within some developed countries with the higher ratio of population (65+) and Human Development Index (HDI). Furthermore, the population ratio (15-64) is itself an explanatory factor that can be used to characterize similar transmission patterns between countries. Consequently, these findings may help state authorities to take urgent precautions and manage such a global epidemic by much more efficient health policies.

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INTRODUCTION

Coronavirus 2019 (COVID-19) is an infectious respiratory disease that affects people and is caused by severe acute respiratory syndrome coronovirus-2 (SARS-CoV-2) [1]. Coronavirus which first appeared in Wuhan China's Hubei in 2019 and has affected the whole world, expressed as a global pandemic by the World Health Organization in March 2020 [2]. A pandemic is described as "an epidemic that occurs over a very large area, transcends international borders, and often affects large numbers of people." When it has an intercontinental spread, it is defined as a global pandemic[3].

In addition to general symptoms such as fever, cough, shortness of breath, muscle aches, sputum production, and neurological symptoms such as diarrhea headache, nausea, and vomiting [3, 4]; loss of sense of smell and taste have been observed in infected individuals [5]. However, the clinical and virological course of this disease has still not been thoroughly elucidated.

According to medical reports, although most of the cases have mild symptoms, serious ones such as severe pneumonia and multiple organ failure have also been observed [2]. All these serious effects are a challenge for governments and push them to take some necessary precautions. For this reason, many countries have executed some necessary precautions such as closing border gates, suspending domestic and international flights and other travels, banning layoffs, accessible free masks, and coronavirus tests, wearing masks outdoors mandatory, giving additional financial support for people, delay of payment and tax, closure of schools and universities for case isolation, the ban on mass gathering and/or public organizations, and local and national quarantines. These precautions aim partially or completely to control the severity of the epidemic by reducing mass mobility.

In the literature, different studies have been conducted to measure the effect of different precautions implemented at separate times on the transmission rate of the epidemic. Georgios et al.(2020) have shown that in England, which is one of the countries with the highest number of cases and deaths compared to the population, human mobility gradually decreases as the health policy implemented by the government [6], [7] This has a significant effect in the decrease of deaths associated with COVID-19. Saez et al.(2020) have used the time series analyzes with daily COVID-19 cases obtained from Spain, Italy, and China, and have concluded that the implemented precautions have reduced the number of COVID-related cases in Spain[7]. In Santamaria (2020), the time-related precautions taken by countries in the European region were examined, and they have shown that these restrictions help the reduction in the transmission rate of the epidemic[8]. Guliyev (2020) worked on the transmission power and effects of COVID-19, and analyses were carried out on infected, healed, and dead cases to explain the factors affecting the transmission of the virus and the relationship among these factors[9]. Flaxman et al. (2020) have used the semi-mechanistic Bayesian hierarchical model to show the effect of non-drug COVID-19 restrictions and the number of infected cases that are estimated in 11 European countries. In their study, the proposed model assumes that each restriction has the same effect on reproduction numbers over time and across countries[10].

This study aims to figure out main factors that have significative impact on the transmission rate of COVID-19 up to the first peak days (plateaus) watched in G20 and EU countries. Also, this study puts forth the effects on COVID-19 transmission rate of the health policies and precautions implemented by the countries with similar economic and demographic characteristics in the G20 and EU. To present the results of analysis and findings obtained from our study, this paper is organized as following. The motivation and overview of this study is explained in Section 2. The short frameworks of FA and MDS are given in Section 3. The outputs of analysis are placed in Section 4. Lastly, the results and conclusions are discussed in Section 5.

Motivation and Overview

After the first coronavirus (COVID-19) case was seen in Turkey on March 11, 2020, the rapid increase in the number of infected individuals made it necessary to test individuals with symptoms with diagnostic kits and to initiate treatment processes for those infected. Each country around the world has implemented various health policies including the closure of schools and universities for case isolation, the ban on mass gathering and/or public organizations, large-scale social distancing, and delay of flights both domestic and international. Even if the precautions mentioned were partially or mostly effective in reducing the impact of the epidemic, the number of cases started to rise again as soon as being relaxed these strict practices in many countries before they reached out to the first wave [1], [2], [11].

Mahmoudi et al. (2020) have used the fuzzy clustering method to show the relation between transmission of coronavirus in seven countries by eliminating population's size effect for countries[12]. In this study, they have shown the number of deaths and the number of patients for the seven countries related to the transmission rate of pandemic based on COVID-19 using Pearson's correlation, and principal component analysis. Singh (2020) have used a multivariate regression model to predict the number of deaths related to COVID-19 for 200 countries by using common taken precautions[13]. Khan et al. (2020) have analyzed the fatal effects of the pandemic by using the number of infections, deaths and recoveries and different preventive measures on the 13 most affected countries from COVID-19 and have showed whether the lockdown was effective in the spreading of pandemic[14]. Li et. al. (2021) used the least absolute shrinkage and selection operator (LASSO) to select the important variables affecting COVID-19 transmission and fatality in 154 countries and in the 50 U.S.

states. According to ridge regression model, the features having significant impact on COVID-19 transmission are age, sex, temperature, humidity, social distancing, smoking, health investment, urbanization level, and race [15].

Baniasad et. al. (2021) has showed the association between COVID-19 transmission rate and environmental factors by using VirSim that is partial of SEIR (Susceptible, Exposed, Infected, Recovered) model that taking account of a country or region. Mobility was highly correlated with COVID-19 transmission, and based on causal analysis, they found that reducing mobility would reduce the rate of COVID-19 transmission with a latency of 6 days (on average)[16].

Zhu et al. (2021) [17] presented a stochastic-based method to model and analyze COVID-19. In the simulation results, it is shown that the proposed method can effectively account for re-infection and social distancing as well as uncertain effects on the spread of COVID-19, providing greater accuracy for the prediction of COVID-19 spread. Gumel et al. (2021) [18] used the McKendrck type epidemic model to evaluate the impact of the COVID-19 vaccine at the potential population level. Also, they have shown how some essential non-drug interventions against COVID-19 can be incorporated into the epidemic model.

In fact, the time taken to reach the first plateau (peak day) varies from country to country in terms of the infected people, depending on many factors such as population, health policies, timing of applied restrictions, etc. Therefore, in this study, the transmission rate is defined as the proportion of infected subjects in the entire population until the first plateau is reached. In the context of examining the considerable impacts of health policies implemented in countries with similar/different demographic characteristics on the transmission rate, the substantial factors can be extracted by means of the multivariate statistical analysis. Uncovering these factors allows the state authorities to under control the negative and deadly effects of global pandemics as soon as possible.

As stated above in the introduction, as soon as COVID-19 was recognized as a global epidemic by the World Health Organization in March 2020, all countries of the world immediately started to take some special precautions and applied restrictions against COVID-19 such as closed of workplaces (universities, business areas, etc.), restriction of events, meetings constraints, public transport restriction, stay at home, domestic and international flight restriction, test policy, etc. However, the enforcement of these direct or indirect sanctions has been a big challenge for the countries, because they have different geographical, demographics, economic and socio-psychological characteristics each other. For this reason, although the timing of such sanctions varies from country to country, the preparation and integration processes of government institutions against the pandemic took time. In addition, in the context of the implementation of such practices, the perception of society has also differed. For instance, within China and the USA, the world's two largest economies, the precautions taken against the pandemic were implemented differently due to their administrative and demographic characteristics.

Rather than the precautions implemented by the countries, the ratios of age groups (15-, 15-64, 65+) within the population and HDI can be seen as other factors that influence the transmission rate. Especially, HDI is a composite index of mortality (life expectancy), the number of educated people, and per capita income indicators. It is expected that when the lifespan is higher, the education level is higher as well as the gross national income GNI per capita. Therefore, HDI can be considered as an explanatory variable in the comprehensive analysis related to COVID-19 transmission. Thus, the effects of global pandemic within the developed and developing countries will be investigated in the context of socio-economical manner.

The G20 (or Group of Twenty), which is an intergovernmental forum comprising 19 countries and EU, focuses on key issues regarding to the global economy, such as international financial stability, sustainable economic development, climate change, reforming the World Bank and IMF, demographic changes, etc. G20 consists of most of the world's largest economies in terms of industrialization and economic development, and it totally accounts for 90% of gross world product (GWP), 75-80% of international trade, two-thirds of the world's population, and half the world's land area [19]. Besides, in the context of conducting large-scale scientific research on the global epidemic, G20 and EU countries have more transparent and reliable databases on COVID-19.

Considering the above-mentioned facts, the main motivation of this study is to figure out significative factors that affect the transmission rate of COVID-19 up to the first peak days watched in G20 and EU countries. Besides, the effects of health policies implemented in countries with similar/different demographic characteristics on the transmission rate of COVID-19 can be interpreted by means of these extracted factors. Thus, this intention allows the state authorities to take more efficient precautions against the global pandemic and manage it more systematically.

To find out remarkable factors, and interpret similar transmission patterns between countries, COVID-19 dataset was examined with using factor analysis (FA) and multidimensional scaling (MDS), respectively. Both these approaches are often used within multivariate analysis because of their flexible and robust theories.

METHODOLOGY

In this study, to find out general factors affecting the transmission rate of COVID-19 up to the first peak in G20 and EU and figure out similar patterns between countries, the factor analysis and multidimensional scaling were utilized. The short frameworks of these techniques are summarized in the following subsections.

Factor Analysis with Principal Axis Factoring

Factor analysis is a statistical technique that is used to reduce the dimension of variables and provides a new orthogonal structure, called as factors [13, 14, 15]. There are two different factor analysis methods, called exploratory factor analysis and confirmatory factor analysis. The most common method in exploratory factor analysis is principal axis factoring (PAF). PAF uses the principal components strategy to create the correlation matrix with computing common variance instead of ones, where diagonal elements are not 1 [21], [22]. These calculations are provided by iterative methods, and the square of multiple correlation of each variable with others is considered as an initial point, and this process continues until the predefined number of iterations is reached. Thus, PAF replaces the diagonal elements of the matrix of association like correlation or covariance matrix with initial communality estimates or initial estimates of shared variance [23]. The purpose of this approach is to reveal the maximum variance at right angles from each successive factor [24]. Besides, PAF no needs to multivariate normality for each variable [16, 18].

Multidimensional Scaling

This method represents measurements of similarity or dissimilarity among pairs of objects by using distances between points of a low dimensional multidimensional space [26]. Specifically, MDS is a family of statistical methods that allows making data analysis and consistent inferences. This may be the reason that MDS tends to be viewed as a data visual technique, and sometimes it is considered with respect to mapping technique [27]. In addition, MDS has mostly been utilized as a tool for analysing proximity data of all kinds (e.g., correlations, similarity ratings, co-occurrence data).

MDS draws alternative way with visualization of distance or dissimilarity with produce of samples in dimensional space, and there is located as strictly as possible among either distances or dissimilarities. The method is embodied to make spatial map of data according to positions of observations, so it allows making easy interpretation of the position of the observations, called as scaling. In literature, there are two common approaches in scaling: Euclidean (classic/metric) and non-Euclidean (non-metric) [28]. To compare the solutions obtained by MDS analysis, the proximity measures based Euclidean metric are city-block, dominance, Minkowski, Canberra, Bray-Curtis, chord distances as well as angular separation, correlation, and monotonicity coefficient [29]. The main motivation for using these metrics is to draw the best graphic that represents the empirical observations well[30].

Specifically, Biplot analysis provides a structure of diversity in MDS where data involves variables and not just dissimilarities [31]. In this way, Biplot analysis allows mapping the external variables on MDS configuration, and establishing validation for variables on dimension [32].

Analysis

COVID-19 dataset used in the analysis were gathered from WHO, Eurostat and official institutes of EU and G20 countries [33]. The variables used in analysis are given in Table 1, and their definitions are described in Appendix I. To find out main factors that affect transmission rate of COVID-19 up to the first plateaus watched in the countries, COVID-19 dataset was analyzed with both FA and MDS using R packages. In the analysis, the insignificant and correlated variables were discarded, and not discussed within the section of the results and conclusions.

Outputs of FA

In analysis, the factors were extracted by principal axis factoring method considering various factor rotation approaches. According to analysis results, varimax rotation provided a better variance explanation than the other approaches. The results of analysis are given in Table 2, and between Fig. 1- Fig. 4.

From Table 2, FA with Principal Axis Factoring extracts three factors. The estimated loadings in the related factors are acceptable because they are greater than 0.4. In analysis, sampling adequacy and uncorrelated variables in the extracted factors were examined with KMO (Kaiser-Meyer-Olkin) and Bartlett's for sphericity test statistics, respectively. From Table 2, KMO test statistics can be considered as miserable (0.50 to 0.59) while Bartlett's for sphericity test puts forth existing uncorrelated variables in the factors. In fact, KMO measure should be greater than 0.70, otherwise it is inadequate if less than 0.50 [34]. Further information about significance tests is discussed in Hair et al.(2009) [35] and Sharma (1996) [36].

According to the analysis results, the first factor covers the cases, infected, death and recovered. The second factor consists of population (15-), population (65+), HDI and peak day. Lastly, the third factor includes only the ratio of population (15-64). From Table 2, it can be seen an interesting output where Ratio of Population (65+) and HDI have negative factor loadings on Factor 2 while the others are positive.

To make the visual analysis with respect to two and three dimensions, the scatter plot of countries according to three factors is shown between Fig.1 and Fig. 4. From Fig. 1, Fig. 2, and Fig. 3, Brazil, USA, and Russia are dissociated from the other countries with respect to the first factor. Especially, Brazil and USA can be interpreted as an outlier in terms of high ratios of infected, cases, death and recovered to their populations.

As seen from Fig.1, Fig. 2 and Fig.4, some countries such as Japan, Italy, Portugal, and Germany have greater HDI and ratio of population (65+) than the other countries in

Table 1. Variables used in FA and MDS

Variables	
Number of tests (up to peak day)	Meetings Constraints
Ratio of population (15-)	Public transport restriction
Ratio of population (15-64)	Stay at home
Ratio of population (65+)	Domestic flight restriction
HDI (Human Development Index)	International flight restriction
Closed workplaces (after the first case)	Test Policy
Restriction of event	Number of recovered
Number of Infected	Number of deaths
Number of Cases	

Table 2. Factor analysis with Principal Axis Factoring

	Factors			**Total Variance**	
	1	**2**	**3**	**Eigenvalues**	**Variance (%)**
Number of infected	0.981				
Number of cases	0.975			4.597	40.671
Number of deaths	0.959				
Number of Recovered	0.930				
Ratio of population (15-)		0.989			
Ratio of population (65+)		-0.905		2.186	30.282
HDI		-0.642			
Peak Day		0.609			
Ratio of population (15-64)			0.978	1.010	13.213.
Total Variance Explained					84.146%
KMO	Kaiser-Meyer-Olkin Measure of Sampling Adequacy				0.564
	Approx. Chi-Square				951.440
Bartlett's Test of Sphericity	df				55
	p				0.000

p: The level of statistical significance; df: degree of freedom

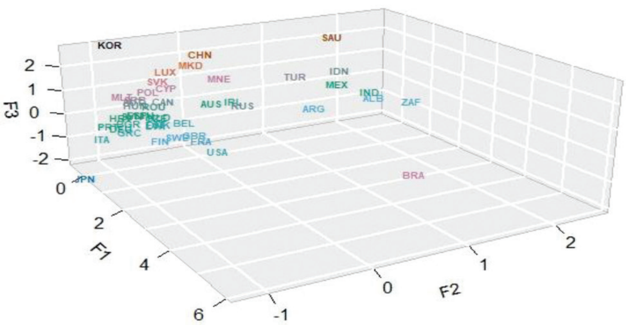

Figure 1. 3D graph of factor analysis.

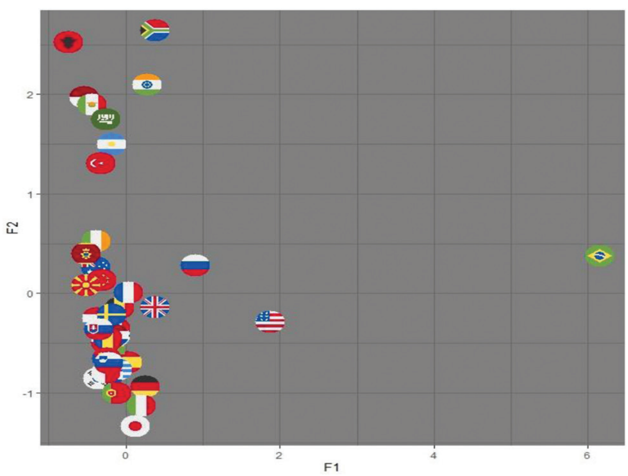

Figure 2. 2D graph with respect to F1 and F2 for factor analysis.

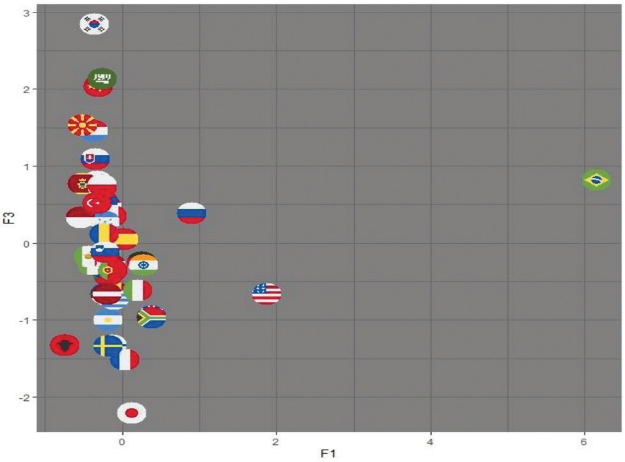

Figure 3. 2D graph with respect to F1 and F3 for factor analysis.

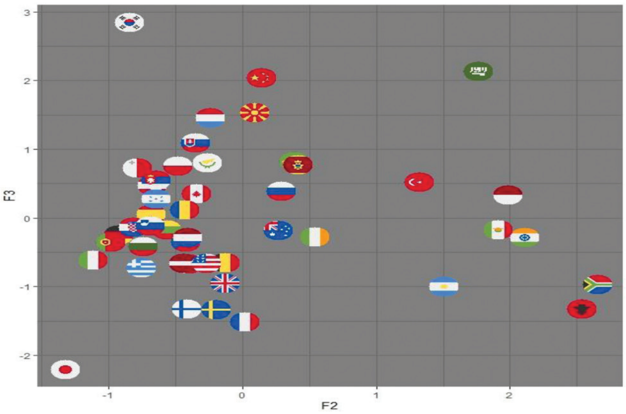

Figure 4. 2D graph with respect to F2 and F3 for factor analysis.

Table 3. Multidimensional Scaling Statistics with Biplots

	Coefficients			R^2
	1	**2**	**3**	
Number of cases	-1.609			0.88
Number of infected	-1.524			0.83
Number of deaths	-1.495			0.84
Number of recovered	-1.495			0.77
Peak Day	-.1.276			0.71
Number of tests	-1.162			0.64
Ratio of population (15-)		1.839		0.83
Ratio of population (65+)		-1.797		0.92
HDI		-1.788		0.68
Ratio of population (15-64)			2.3793	0.71
Multidimensional Scaling	**Permutation test**			p<0.0001
	Stress value			0.077

R^2: Coefficient of determination; **p:** The level of statistical significance

the second factor. On the other hand, some countries having high (15-) age population such as India, South Africa, Albania, Indonesia, Saudi Arabia, Argentina, Mexico, and Turkey are separated from others like a group.

From Fig.1 and Fig.4, it can be concluded that the third dimension allows making noteworthy inference in terms of separating countries with respect to the ratio of population (15-64). Specifically, due to high (15-64) age population, certain countries such as South Korea, China, Saudi Arabia, Luxemburg, and Macedonia have showed similar patterns related to COVID-19 transmission. On the other hand, some countries having low (15-64) age population such as Japan, France, Finland, Sweden, and Albania have been affected by pandemic similarly.

Outputs of MDS

In this section, as an alternative to FA, the multidimensional scaling biplot analysis was used. To improve the efficiency of dimension extraction, primarily distance methods such as Canberra, Euclidean and Manhattan were handled. According to analysis results, Euclidean distance has brought out the most efficient outputs with respect to stress value and permutation test as well as the scores on the extracted dimensions. All the outputs and test statistics related to MDS analysis are given in Table 3, and the scatter plot of countries according to three dimensions is shown between Fig.5 and Fig. 8.

The smaller stress values in MDS biplot provide more effective dimensions in terms of goodness of fit assessments.

On the other hand, the permutation test creates a stress sampling distribution under the hypothesis of fit/misfit, and it establishes the evaluation of stress value. [29], [37]. According to analysis results given in Table 3 and Fig. 5, MDS biplot produces three dimensions which can be interpreted as the optimum scales. From Table 3, the estimated stress value (0.077) falls within fair value range (0.05 – 0.099), and permutation test is significant ($p<0.0001$) [38]. Also, individual R^2's for each variable that represents the parts of explained variance in MDS Biplot analysis seems plausible.

According to outputs of MDS, the first dimension includes the numbers of case, infected, death, recovered and peak day, respectively. The second factor consists of population (15-), population (65+) and HDI. Lastly, the third factor covers only ratio of population (15-64). From Table 3, it can be inferred that factor analysis and MDS produced related results, because the extracted dimensions consist of same variables with factor analysis apart from peak day where it is included by the second factor. However, peak day has moved in the first dimension at MDS. Also, all the coefficients of variables in the related dimensions are negative, out of Ratio of Population (15-64) and Ratio of Population (15-64) in the second and third dimensions, respectively.

From Fig. 5, Fig. 6, and Fig. 8, it can be easily seen that Brazil, USA, Russia, India, South Africa are dissociated from the other countries with respect to the first factor. This case is quite a like the results obtained by factor analysis, out of India, South Africa. Especially, Brazil can be interpreted as an outlier in terms of higher ratios of infected, case, death and recovered numbers to their populations.

As seen from Fig.5, Fig. 6, and Fig.7; due to high HDI and (65+) age population in the second dimension, certain countries such as Japan, Germany, Italy, and Finland have similar patterns. On the other hand, some countries having higher Ratio of population (15-) such as India, South Africa, Indonesia, Albania, Mexico, Saudi Arabia, Brazil, Turkey, and Argentina have dissociated from the other countries.

As seen from Fig.5, Fig. 7 and Fig. 8, South Korea, Saudi Arabia, China, Macedonia, Luxemburg, and Brazil have

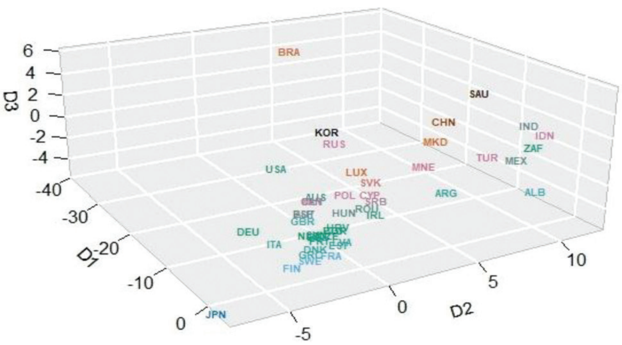

Figure 5. 3D graph of MDS.

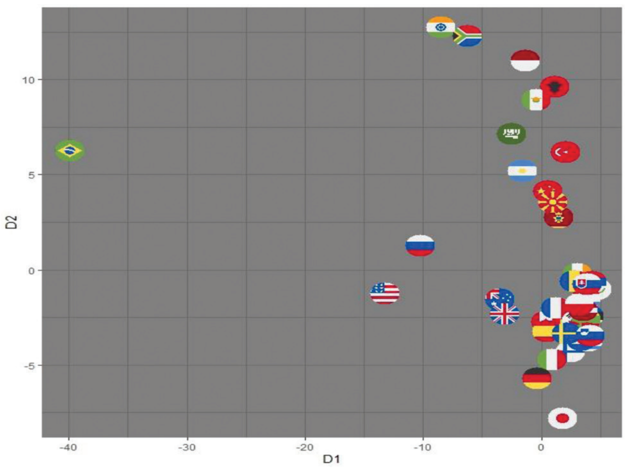

Figure 6. 2D graph with respect to D1 and D2 for MDS.

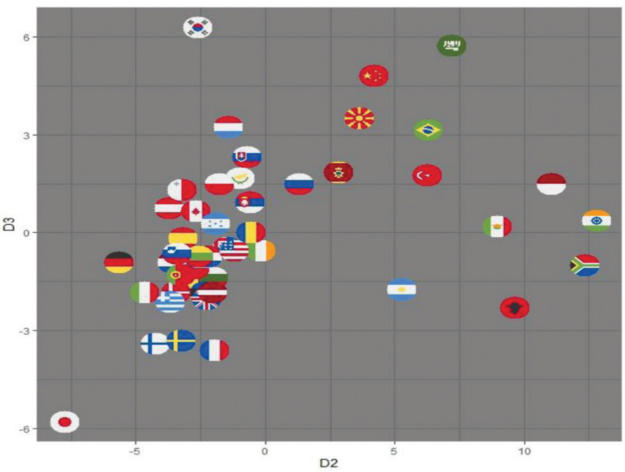

Figure 7. 2D graph with respect to D2 and D3 for MDS.

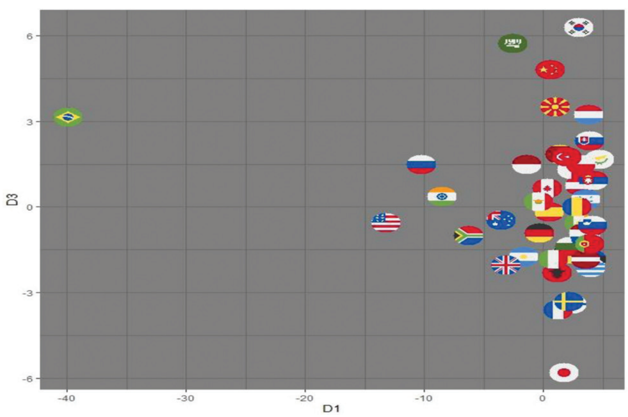

Figure 8. 2D graph with respect to D1 and D3 for MDS.

showed similar patterns against pandemic due to higher ratio of population (15-64). On the other hand, some countries having lower ratio of population (15-64) such as Japan, France, Sweden, Finland, and Albania have been affected by pandemic similarly. These results are remarkably like ones obtained from factor analysis above.

RESULTS AND CONCLUSIONS

From the results of multivariate analysis, FA and MDS were successful in revealing the explanatory factors affecting the transmission rate of COVID-19. Thus, these extracted factors allow making meaningful inferences about the transmission patterns up to the first plateaus watched in G20 and EU countries. Also, multivariate analysis figures out the effects of the precautions and health practices implemented by G20 and EU countries with similar/different socio-economic development characteristics on the transmission rate. Besides, by means of these explanatory factors, G20 and EU countries were grouped with respect to similar/different socio-economic development characteristics and implemented health policies.

The meaningful inferences obtained from multivariate analysis are summarized as following. For instance, one of the notable implications is that the high (65+) age population and HDI couple have a significant impact on the COVID-19 cases seen in countries. Especially, developed countries such as Japan, Germany, Italy and Finland, Portugal, and Sweden, etc. have disassociated from the others due to their high HDI and elderly populations.

Another worthy inference from analysis is that (15-64) age population comes forward an efficient feature to affect the transmission rate. Therefore, it only constitutes the third factor by itself in the FA model and has the most weight in the third dimension of the MDS. From the visual analysis, certain countries having high (15-64) age population such as South Korea, China, Saudi Arabia, Luxemburg, Macedonia, and Brazil have showed similar patterns against COVID-19 transmission. On the other hand, some countries having lower (15-64) age population such as Japan, France, Finland, Sweden, and Albania have showed similar patterns as well.

According to the first factor (Cases: total case, infected, death, recover) and dimension (Cases, the number of test and peak day), Brazil has clearly become distant from the other countries. In fact, this situation can be interpreted as that Brazil has faced with quite different COVID-19 cases from other countries. In this context, Brazil is followed by USA and Russia. As seen from Fig. 1 and Fig. 5, the developed and developing countries are clustered into two groups with respect to three factors and dimensions. That is, COVID-19 pandemic watched differently in developed and developing countries up to their first plateaus. In MDS analysis, the number of performed PCR tests is covered by the first dimension together with total case, infected, death and recover. This situation clarifies that performing many PCR tests is related to the number of cases.

According to multivariate analysis results, the implemented precautions and bans such as stay at home (including closing school), restrictions of events and domestic/international flights were not found to be a significant factor, because G20 and EU countries put into practice them in a brief time after the first announcement of the global pandemic. Therefore, these implementations do not make any significant difference among the countries statistically. However, it is vital that these restrictions are implemented as quickly as possible in the initial stages of the pandemic.

Consequently, these findings may help state authorities to take urgent precautions and manage such a global epidemic more systematically. In the light of the mentioned inferences above, the developed countries having higher (65+) age population and HDI should provide emergency health precautions for the elderly in the early part of the pandemic. Having a population aged (15-64) is a factor that directly affects the rapid spread of covid-19 in the early days of the pandemic, because they correspond to a large part of the business world. For this reason, workplace controls and working from home (or stay at home) should be encouraged to under control the spread of the virus during the early stage of pandemic. In addition, strict controls or bans should be implemented on domestic and international transportation as soon as possible. Besides, the performing of many PCR tests is very crucial, because it helps to clarify the exact number of infected people in the population. Thus, the state authorities might manage the capacity of hospital emergency units and drug stocks more effectively.

As a future direction, we are planning to extend our study to all countries of the world and examine more comprehensive features for the second and third plateaus.

Conflict of Interest:

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Availability of data and materials

The data used is available and will be provided by the corresponding author if necessary.

List of abbreviations

COVID-19: Coronavirus 2019

SARS-CoV-2: Severe Acute Respiratory Syndrome Coronovirus-2

FA: Factor analysis

MDS: Multi-dimensional Scaling

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

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APPENDIX I.

<u>Definition of variables:</u>

Population (Age Groups: 15- ,15-65, 65+):

To examine the impact of age groups on the transmission rate, the population is petitioned into three subdivisions: below 15, between 15 and 65, and above 65. In analysis, the ratio of each age group to the total population was used, because the ratio scale provides more valuable information than interval scale.

Human Development Index (HDI):

HDI is a composite index of mortality (life expectancy), the number of educated people, and per capita income indicators. It is expected that when the lifespan is higher, the education level is higher as well as the gross national income GNI per capita. Therefore, HDI can be considered as an explanatory variable in the comprehensive analysis related to COVID-19 transmission.

Closing Workplaces (After the First Case):

Time from first case of COVID-19 to closure of businesses.

Restriction of Event:

Time from the first case of COVID-19 to restriction of event.

Meetings Constraints:

Time from the first case of COVID-19 to implemented meetings constraints.

Closing the Schools

Closure of school is the policy of the education system and the school regarding distance education. Time from the first case of COVID-19 to closing the schools

Public Transport Restriction:

It is the restriction of all public transport restrictions, including metro and ferry services, and the temporary closure of highways, airports, and train stations. Time from the first case of COVID-19 to these restrictions.

Stay at Home:

Stay at home orders are the physical distancing interventions to slow the transmission of the virus. Time from the first case of COVID-19 to the announced of stay at home.

Domestic flight Restriction:

Domestic transportation has a considerable impact on spreading the virus. Domestic COVID-19 restriction helps to be taken under control spreading virus by transportation systems such as buses, trains as well as limited domestic flights. Time from the first case of COVID-19 to the announced domestic flight restriction.

International flight Restriction:

Since passengers from high-risk countries increase the transmission of the virus, countries put some restrictions such as suspending flights or requesting a PCR test. Time from the first case of COVID-19 to the announced international flight restriction.

Cancellation of Event:

Cancellation of public events prevents the spreading of the virus. It is time from the first case of COVID-19 to the announced cancellation of event.

Peak Day (Plateau):

The day of the epidemic peaks or plateaus - when a country “flattens the curve.”

Number of Tests (up to peak day):

The number of tests is performed to make diagnosis to peak day (PCR or similar tests).

Number of Cases (up to peak day):

Any person meeting the laboratory confirmation of COVID-19 infection is defined as a case.

Number of Deaths (up to peak day):

The number of deaths shows us the severity of a disease, identify populations at risk, and determine the quality of healthcare.

Number of Recovery (up to peak day):

The number of patients who recovers to peak day.

Number of Infected People (up to peak day):

The number of infected people is calculated by subtracting recovery and deaths from total cases.