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Examining the World's Countries in Terms of Outbreak, Control, and Vaccination against COVID-19

Abstract

More than two years have passed since the emergence of COVID-19 challenging all countries worldwide. this study was conducted to examine the world's countries in terms of outbreak, control, and vaccination against COVID-19

This study is descriptive-analytical. The published files associated with COVID-19 data in World Health Organization from December 2019 to December 2021 were used as a statistical population. these data were analyzed through data mining and using R software. k-means algorithm was employed for clustering.

The results of this clustering indicated that the countries in the third cluster have undergone the worst level of damage in terms of variables related to outbreak and pathogenicity, though they have had a better performance in terms of public vaccination compared to the countries of other clusters. The counties in the second cluster were found to be less afflicted in terms of transmission, mortality, and active cases, but regarding individual recovery, the number of tests taken, and the variables related to public vaccination, the first cluster counties have shown a better performance. Further, the global map resulting from this clustering shows that most countries of each cluster share borders and our neighbor countries. The first cluster countries lie between the second and third clusters, and the third, second, and first cluster countries have large, average, and small areas, respectively.

The performance of different countries against covid19 showed that more effective control of the pandemic depends on a set of prevention strategies through general vaccination, diagnostic and control measures.

Keywords: *COVID-19, Response strategy, Vaccination, Quarantine, Diagnostic tests.*

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Introduction

More than two years have passed since the extensive outbreak of COVID-19. This pandemic confronted all counties with a new challenge worldwide. At the beginning of the emergence of this disease, despite extensive signs of progress in science, the most powerful countries were also surprised by this unknown disease and did not show a remarkable performance against it [1-3]. Covid-19 pandemic incurred massive damages to human societies, such that from the beginning of its outbreak up to 20 January 2022, 336,790,193 confirmed cases of COVID-19, with 5,560,718 deaths have been reported to WHO. Also, up to 19 January 2022, overall 9,571,502,663 doses of vaccine have been administered (4). Delay in diagnosis and response in China, the USA, and European countries such as Italy, Spain, and Britain led to delays in implementing control measures. These counties failed in predicting the effect of the pandemic within their boundaries and recorded the highest mortality rate worldwide (5,12). It also caused the healthcare systems to be attacked massively by patients. Meanwhile, some other counties such as Singapore, Taiwan, Hong Kong, and South Korea were successful in controlling COVID-19. They considered effective strategies for containing COVID-19 and from the beginning of the pandemic, they reported very few cases of the disease (13,14). WHO identified 13 African counties including Algeria, Angola, Cote d'Ivoire, Congo democratic republic, Ethiopia, Ghana, Kenya, Morris, Nigeria, South Africa, Tanzania, Uganda, and Zambia as counties with the highest risk of infection with limited resources against COVID-19 (13). In studies performed on controlling COVID-19, so far healthcare and medical geography, as well as healthcare and medical policies have remained understudied (15). Considering the rapid and extensive spread of this disease through the air and the inevitable interactions among different societies especially in neighboring countries, as well as genetic, cultural, social, and other similarities of these counties, extraterritorial and international communications, as well as the inability of some countries in providing the resources required for tackling this disease, global approaches are essential for controlling COVID-19 (3,16,17). The past experiences of different counties indicated that local decisions on confronting this disease can influence the global community. Thus, the performance of different counties worldwide over the past two years based on the data published by these counties regarding COVID-19 and their current status should be examined, as it helps in decision-making on selected global strategies for controlling this pandemic. The studies conducted so far have examined the measures taken by countries individually or for a group of counties. This study intends to explore the performance of world countries in confrontation with the COVID-19 pandemic. The main aim of this research is to cluster counties based on 11 variables out of the WHO's reported variables. It deals with examining the vulnerability resulting from the pathogenicity and spread of coronavirus,

vaccination, and geographic location of counties in each cluster.

Material and methods

The present applied research was performed via an analytical-descriptive approach cross-sectionally. To perform this study using keywords COViD-19, response strategy, vaccination, quarantine, medical technology, and diagnostic tests in PubMed, Scopus, and Elsevier databases, the papers were searched whereby 115 papers were extracted. After examination, eventually, 35 papers were used. Further, the data of 11 variables recorded by WHO were used including name of country, total cases, total mortality, total recovered individuals, total active cases, total tests taken, the country's population, total vaccinated individuals, total number of partially vaccinated individuals, total fully vaccinated individuals, the number and type of vaccines used against COVID-19 from December 2019 to December 2021 for 185 countries.

This research which was performed to explore the vulnerability of different counties and their performance against COVID-19 employed the clustering method, which is a practical and well-known data mining method. Data mining is an important step in "discovering knowledge from databases". This process is realized through data cleaning, data integration, data selection, data transformation, data mining, pattern evaluation, and knowledge presentation steps. The first four steps are indeed data pre-processing stages, in which data are suitably converted for data mining algorithms (18). Data analysis in the present research has been performed by R software. Since some variables are highly interdependent, their direct usage was virtually impossible. Thus, through principal factor analysis, the principal components were extracted from the dependent variables. For this purpose, through a parallel method and based on the eigenvalue of the correlation matrix, the number of principal components was obtained and the main components were calculated. Eventually, using the new dataset, the available counties were clustered through the k-means algorithm. k-means algorithm is one of the simplest yet well-known clustering algorithms. The number of clusters in this method is constant and should be determined by the user. Briefly, the steps of implementing the k-means algorithm here were as follows:

1. The observations were included randomly in the k determined clusters;
2. The mean or center of variables was calculated in each cluster;
3. The distance between each observation and the center of the cluster itself was calculated;
4. the member with maximum distance from the center of its cluster was interchanged with the cluster with the minimum distance with it;
5. The four previous stages were replicated until the displacement of observations no longer occurred.

Note that to estimate the suitable number of clusters, there are various methods including the total within-cluster sum of squares (WSS), Average Silhouette, methods based on Gap statistics, and majority rule (19). Since for the clustering, the optimal number of clusters should be estimated, using four conventional methods, the optimal number of clusters was extracted and the clustering operation was performed. At this stage, the significance of the factors extracted during the clustering should be determined, for which misclassification rate has been used. Eventually, the features and characteristics of countries in each cluster as well as their differences were examined, and their maps were drawn.

The pre-processing performed in this research was as follows:

- Estimating missed data of total case, total death, total recovery, and active case using their relation:

$$\text{total.case} = \text{total.death} + \text{total.recovery} + \text{avtive.case}$$

- Eliminating counties for which some data had not been reported except for the above case.
- Dividing all variables by the population variables.
- Normalizing and descaling the data using the Minimax method. That is,

Hence, all variables lay within the [0,1] range.

- Analyzing the principal components and converting the dataset to a three-dimensional set.

Results

After applying four operations of data pre-processing, the last stage, i.e. principal components analysis was done. three principal components for the normalized data. The Scree test plot based on eigenvalues (blue), the mean eigenvalues obtained from random data (red), and eigenvalues larger than 1 (horizontal line y=1) are outlined in Fig. 1. All three methods proposed three principal components for normalized data.

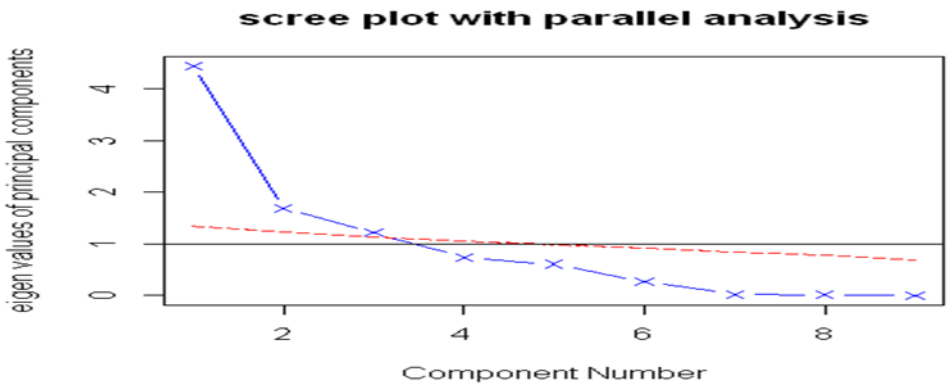

Fig. 1. Scree test plot

Table 1 reports the values of factor loads, and the variance explained by each variable via all three principal components. For example, the factor load or correlation of the total case variable with the first, second, and third components has been 0.31, 0.88, and 0.3 respectively. These three components have accounted for about 0.96% of the variance of the total case variable and failed to capture 0.04 of it.

Considering the vertically rotated factor loads in Table 1, it is found that:

The first component RC1 was defined based on three variables related to vaccines, i.e. Total vaccinations, Persons fully vaccinated, and Persons fully vaccinated.

- The second component RC2 was defined with three variables related to transmission, i.e. total case, total death, and total recovery.
- The third component RC3 was also defined based on three variables of an active case, total test, and number type.
- The two first components had a positive correlation with all variables, while the third component showed a positive correlation with active case and total case and a negative correlation with number type. It signified that with an increase in the number of number types of vaccines, the active case and total case would diminish and vice versa. This was one of the important and interesting outcomes obtained from this section.

Variables	RC1	RC2	RC3	h2	u2
Total case	0.31	0.88	0.3	0.96	0.043
Total death	0.05	0.90	-0.08	0.82	0.179
Total recovery	0.31	0.88	0.14	0.88	0.118
Active case	0.13	0.31	0.62	0.5	0.502
Total test	0.46	0.28	0.49	0.53	0.471
Total vaccinations	0.96	0.22	0.05	0.98	0.024
Vaccinated 1plus dose	0.97	0.17	-0.02	0.97	0.029
Persons fully vaccinated	0.97	0.18	0.03	0.97	0.026
Number type	0.16	0.15	-0.83	0.73	0.267

Table 1. Vertically rotated factor loads

Estimating the optimal number of clusters

The optimal number of clusters with the principal components was extracted and introduced into the K-means algorithm as input. Various methods were used to calculate the optimal number of clusters. All of these methods have estimated the optimal number of clusters as three.

Fig. 2 provide information based on the clustering diagram drawn for different Ks in Diagrams. it was found that K=3 was the optimal number of clusters that can be considered for the data.

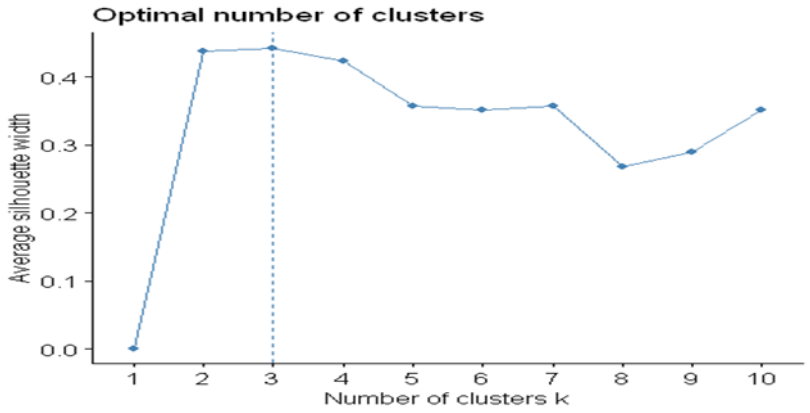

Fig. 2. The diagram is based on the Silhouette method

Based on the clustering diagram drawn for different Ks, it was found that K=3 was the optimal number of clusters that can be considered for the data.

The results obtained from clustering

Fig. 3 presents the values of all three components in the third cluster that was positive. In the first cluster, the first component had small positive values, while the second and third components showed negative values smaller than -0.2 In the second cluster, the values of all three clusters were negative and larger in absolute terms than the values of the first cluster.

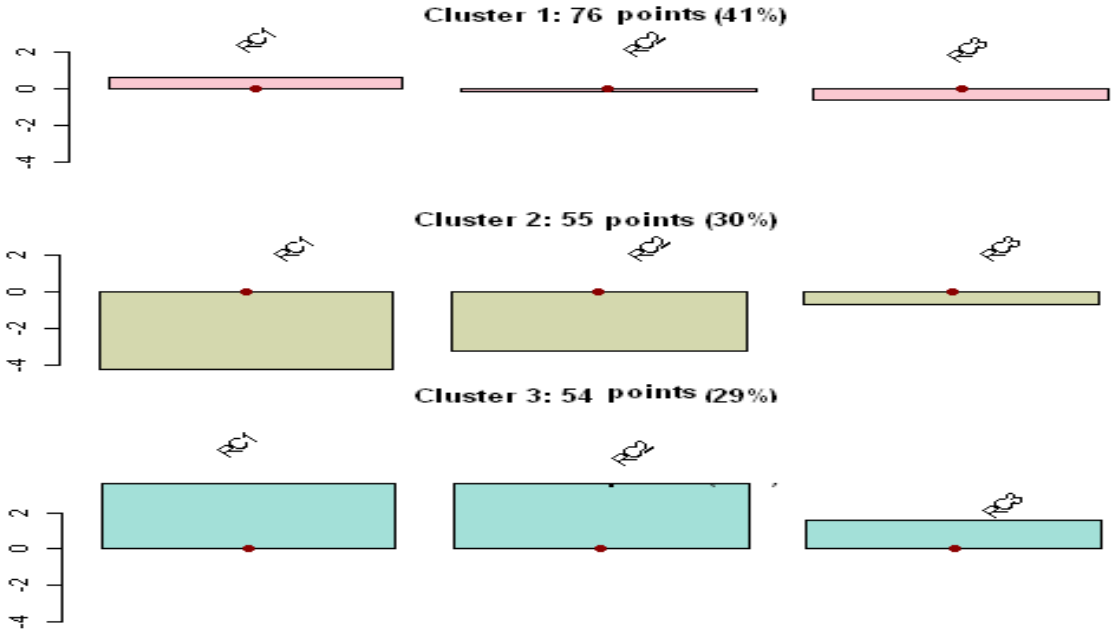

Fig. 3. The diagram of results obtained from clustering

Discussion

In the clustering process, the population variable had not been used directly, rather all variables except for the number type of vaccines were divided by the population. Thus, for better interpretation, the centers of the principal variables in each cluster were divided by the center of the population of that cluster and expressed as a percentage. This has been shown in Table 2, based on which the following findings can be stated:

- The percentage of all variables in third cluster countries including China, Russia, Iran, Canada, etc. has been higher compared to the other clusters. Note that in this cluster considering the measures taken by countries in vaccination and tests taken, showing a higher percentage compared to the other two clusters, the percentage of active cases is still far higher than the countries of this cluster. This can have different reasons, which can be specifically of interest to medical science, genetic, and environmental researchers. In the third cluster, the percentage of recovered individuals is also high, and considering the high percentage of active cases, the effect of vaccines on new variants of coronavirus can be mentioned. Generally, it can be stated that the countries in the third cluster

have topped other countries in terms of rate of mortality and less active cases along with vaccination, recovery of individuals, and tests were taken. This means that regarding transmission and mortality, they are considered dangerous countries, but in terms of vaccination and tests are taken as well as the recovery of individuals they can be regarded as successful countries in fighting this disease.

- When comparing the first and second clusters, it is observed that the percentage of variables is higher in the first than in the second cluster; the second cluster countries including Afghanistan, Pakistan, and most African countries are considered better than the first cluster countries in terms of transmission, deaths, and active cases, but regarding recovery of individuals, the number of tests taken, and vaccine-related variables, the first cluster countries such as USA, Brazil, and Argentina are better. Considering the high active cases in the first cluster compared to the second one and the high rate of recovery increased cluster, the effect of the vaccine in the first cluster which higher vaccination rates can be deduced.

As seen in Table 2, Generally, regarding variables of vaccination, recovery rate, and tests taken per population, the third, first, and second cluster countries have had a better performance respectively. This can be attributed to the performance of governments and the healthcare services provided, observing preventive protocols by the public, and other factors that should be investigated by specialists in different sciences. Meanwhile, the total number of cases, total deaths, and total active cases per population were lower in the second, first, and third cluster countries respectively.

cluster	1	2	3
Total case	2.63	0.78	14.52
Total death	0.05	0.02	0.23
Total recovery	2.45	0.72	11.73
Active case	0.12	0.04	2.55
Total test	43.79	7.18	223.78
Total vaccinations	133.48	32.24	163.52
Vaccinated 1plus dose	68.72	20.16	78.11
Persons fully vaccinated	55.85	13.47	67.98

Table 2. The centers of principal variables in relation to the population (%)

As shown in the map in Fig. 4, most of the first cluster countries are neighbors, which also applies to the second cluster as well (14,15). Considering the third cluster, this also holds relatively. Another notable point is the concentrated form of the second cluster, most of which is in the middle of the map. The third cluster countries have been located between the first and second cluster countries. Indeed, it is found that most countries of the first, second, and third clusters have large, average, and small areas respectively, whereas the high percentage of disease in the third cluster could be due to transmission from large and average-sized neighbors.

Note that in the map of Fig. 4, the countries in grey did not have information sent to the WHO in one or several or all features.

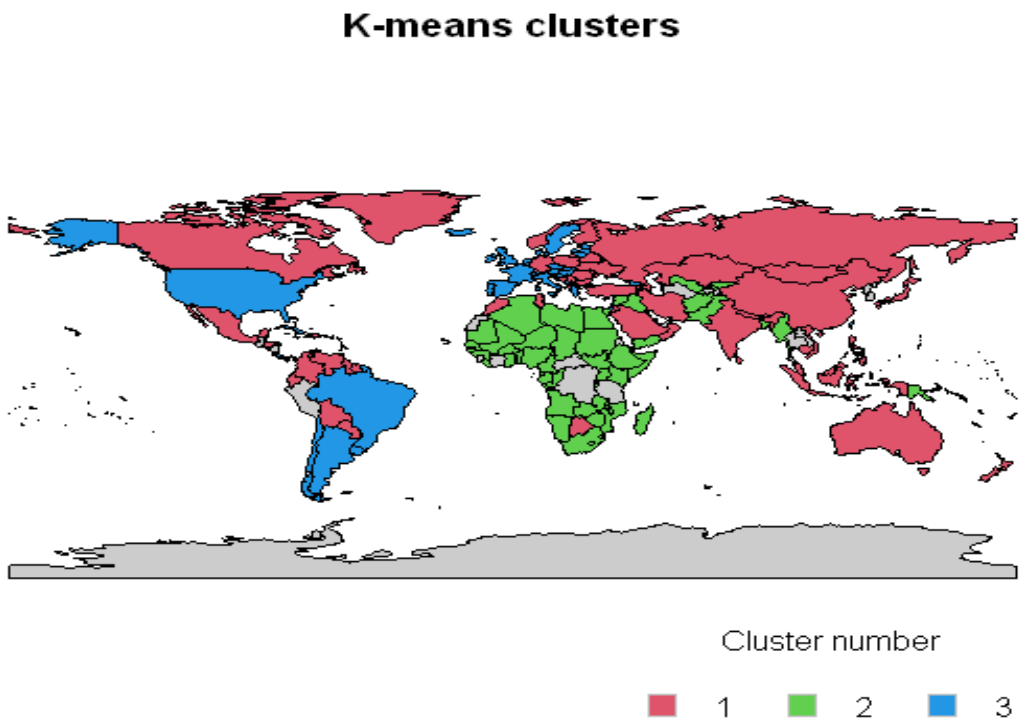

Fig. 4. The map of countries in terms of clustering

Conclusions

The performance of different countries against covid19 showed that more effective control of the pandemic depends on a set of prevention strategies through general vaccination, diagnostic and control measures. Preventive measures taken by governments including quarantine have been effective along with supplying personal protective equipment and hand sanitizers, providing the financial security for people during the quarantine period, measures for identifying and screening cases through extensive and free distribution of diagnostic kits, as well as novel technologies in identifying, screening, following up, and supporting the diagnosis and treatment of COVID-19. Public trust in the government in different countries helps in controlling and preventing the progression of this outbreak (12). Since the relationship between different countries is inevitable and tackling COVID-19 requires a global approach (17, 20), thus accuracy and speed of information provision are essential (21,22). According to the findings of previous studies, currently, the most effective measure taken by governments in controlling COVID-19 is vaccination (8, 16, 23-28). Therefore, so far no definitive treatment has been found for COVID-19, and over time different mutations of this disease emerge (29), COVID-19 is still considered a public health threat. Thus, the only way to tackle this disease seems to be sharing knowledge and experience of countries with each other as well as providing equality for various countries regarding preventive measures and vaccination.

Limitations

the data published by the World Health Organization were not available to all countries. We are also concerned about the accuracy and transparency of the data, especially in countries with dictatorial regimes or countries at war.

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Conflict of interests

Conflictos de intereses: ninguno

Author's contributions

RE and AM were responsible for the study design. RE was responsible for data and statistical analyses and wrote the initial draft of the manuscript. authors reviewed and agreed upon the final version of the manuscript

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Ethics Statement

This study was approved by Department of Health Care Management of Islamic Azad University .

Abbreviations

WHO: World Health Organization

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