

## Impact of vaccines on the COVID-19 pandemic in Turkey

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**Abstract** – COVID-19 (coronavirus disease-2019 pandemic continues to threaten public health and this situation is raising great concern all over the world. With the development of different vaccines, it was aimed to end the epidemic and increase community immunity in the past years. The research reduced public anxiety but the extent of the impact of vaccines in the pandemic is should be under investigation. Because the degree of availability of the COVID-19 vaccines was differing both nationally and globally. This makes it important to investigate how effective vaccination is on the epidemic. The main aim of this study is to investigate the possible recovery impact of vaccination on the COVID-19 pandemic in Turkey. In addition, the rates of severe disease during the first 3 doses of vaccination were also examined in this study. The analyses are conducted based on Spearman, Kendall and Pearson's correlation by using the data of the Ministry of Health of the Republic of Turkey. The obtained results showed that there are strong correlations between vaccination and recovery.

**Keywords** – Coronavirus, COVID-19, Vaccination, Data visualization, Information Engineering, Computable statistical analysis

### I. INTRODUCTION

In today's information age, the concept of data has become increasingly important while the technological developments are progressing very rapidly. Data collecting, using of collected data, analyzing the data and making predictions by using the valid data show how important this is. Data mining techniques help to reveal unpredictable situations. Today, data mining and analysis techniques are used in many fields such as healthcare, market basket analysis, customer segmentation, fraud detection, bio informatics etc. The practice of detecting data patterns and trends in order to extract significant information from a large data set so that we can assess or decide is known as data mining. Many data mining techniques, such as association, classification, clustering, decision trees, prediction, and neural networks, have been developed and used in data mining research. Each methodology has its own set of rules and techniques that define the type of problem it can handle. One of the most well-known data mining approaches is association, which finds patterns based on the relationship between variables in the same transaction. It takes advantage of the relationship between units to discover the most frequent occurrences of different units within the given dataset. While the value of datasets and their applications become popular, powerful analytical platforms are developed to capable of handling massive volumes of data. R and Python are two free and open-source software data mining platforms as commonly used in research [1].

Education, business, marketing, army, communication, engineering, and health care are all reliant on innovative technology applications nowadays. From defining symptoms to accurate diagnosis and computerized patient triage, the health care center is a critical industry that must heavily utilize emerging technologies. In 2019, the world was faced with a virus called COVID-19 (Coronavirus) in Wuhan, China [2]. As of May 16, 226 countries and territories around

the world have reported a total of 521,366,398 confirmed cases and a death toll of 6,288,682 deaths [3]. The effects of the virus were so visible and caused many challenges in fields like global healthcare, economics, and social [4]. Populations who are disadvantaged and have unprivileged lives have had to deal with the effects of COVID-19 in different life conditions like poverty [5]. Some businesses needed to shut down, and some others needed to figure out new strategies to become successful [6]. The medical, economic, and sociologic effects of the COVID-19 pandemic are being studied by researchers all over the world. Many distinct disciplines are attempting to identify solutions and develop strategies for a vast scope of very difficult obstacles. In the history of the world, humans have been faced with pandemics and epidemics, and the most common and well-known way to get rid of the viruses is by discovering and getting vaccinated as a whole community [7]. Vaccines are a great way to develop an immune system by creating proteins to fight viruses without getting really sick [8]. In pandemics like COVID-19 To reach a "Herd immunity" also known as "population immunity" is playing a crucial role and in order to achieve it, Either a great amount of the population needs to get vaccinated or they needs to develop their immune system from the previous sicknesses [9]. So many organizations like the World Health Organization (WHO) never supported the idea of allowing people to spread the virus among one another to increase public immunity, but the organization supported the idea of increasing public immunity through vaccination [10]. The first case of Turkey has been recorded at March 11, 2020 [11]. The total number of vaccines in Turkey as of April 22, 2022 is 147,416,299. The total number of individuals who received the first dosage was 57.811.079, and the total number of people who received the second dose was 53.024.115. 2.898 people were infected,

and 17.808 people recovered from the disease [12]. In this study we used open-source data mining platform R to detect an association level between vaccination and COVID-19 recovery situations in Turkey.

This study contains three steps: First, the dataset that includes information about the total and daily cases, the total-daily deaths, the total-daily recovery, the total-daily recovery, the numbers of seriously ill cases and the total-daily applied doses was collected from the website of the Ministry of Health of Turkey [13,14]. Second, preprocessing is applied to the collected dataset. The duration of the dataset which is being studied is limited between the 13th of January 2021 and the end of April 2022. Because the COVID-19 case data of Ministry of Health of Turkey in not including the ill cases criteria after the first six months of 2021, the study continued with the two different datasets to find the relation between the COVID-19 vaccination and the seriously ill. The first one of our datasets includes the daily and total cases and the first four dosages of the COVID-19, and the second one includes the first two dosages of the COVID-19 vaccinations and the monthly average number of seriously ill cases. In the data preprocessing stage, the missing values of datasets assumed as zero. Third, the created dataset is analyzed by using R platform with the three correlation analysis techniques. The datasets was released for use at GitHub (<https://github.com/ElmasDilara/Covid19-Vaccination-Case-Dataset-TR>).

II. MATERIALS AND METHOD

In this study, analysis are conducted based on Spearman, Kendall and Pearson correlation by using the data of the Ministry of Health of the Republic of Turkey [13, 14].

A. Spearman, Kendall and Pearson correlation techniques

Correlation is a bivariate study that determines the strength of connection and the direction of the relationship between two variables. The correlation coefficient ranges from +1 to -1 in terms of the strength of the association. If this correlation coefficient value equals to 1, this means that the two variables are perfectly associated. As the correlation coefficient value approaches 0, the relationship between the two variables will get lower. The direction of the association is reflected in the sign of the coefficient; a positive result implies a positive relationship, while a negative result shows a negative relationship. In most cases, four types of correlations are measured in statistics: Pearson correlation, Kendall rank correlation, Spearman correlation, and Point-Biserial correlation [15]. Three different correlation approaches were used in this study; Kendall, Spearman and Pearson.

The Pearson product-moment correlation coefficient (abbreviated as r) is a measure of the strength of a linear link between two variables. The Pearson correlation value, r, reflects how far away all these data points are from this line of best fit (i.e., how well the data points fitted this new model/line of best fit) [16]. The Pearson correlation coefficient, r, can be a value between +1 and -1.

Spearman's correlation coefficient is a statistical measure of how strong a monotonic link between two sets of data is. In a sample it is denoted by  $r_s$  and it has the same interpretation

as Pearsons: the closer  $r_s$  is near +1, -1, the stronger the monotonic association:

- .00-.19 “very weak”
- .20-.39 “weak”
- .40-.59 “moderate”
- .60-.79 “strong”
- .80-1.0 “very strong” [17]

Kendall rank correlation is a method of calculating the correlation between two variables. Also called "Kendall's tau coefficient." Kendall's Tau coefficient and Spearman's rank correlation coefficient both evaluate statistical connections based on data rankings. Kendall rank correlation (non-parametric) is an alternative to Pearson's correlation when the data you're dealing with fails one or more of the test's assumptions (parametric). This is also the best solution to Spearman correlation if the sample size is limited and there are numerous tied ranks (non-parametric) [18].

III. RESULTS

There are two approaches for identifying vaccination effect on COVID-19 cases in this work. The first examines recovery amounts, whereas the second examines the amount of critically ill cases.

A. Correlation Between Vaccination And Recovery

In this analysis part, we used first dataset to detect an association between vaccination and recovery criteria. The first dataset contains total cases, daily cases, total recoveries, and daily recoveries, total doses of vaccination, first dose of vaccination, second dose of vaccination, third dose of vaccination, and fourth dose of vaccination. The dataset is analysed using three different methodologies in R Studio: Kendall, Spearman, and Pearson. Table 1 shows the association is so strong between vaccination and recovery.

Table 1. Vaccination Doses and Recovery Correlations

Methods	1.Doses	2.Doses	3.Doses	4.Doses	Total Doses
Kendall	0.9997	0.9982	0.9353	0.89294	0.99973
Spearman	0.9999	0.9998	0.9775	0.95311	0.99999
Pearson	0.8118	0.8577	0.9634	0.93669	0.90079

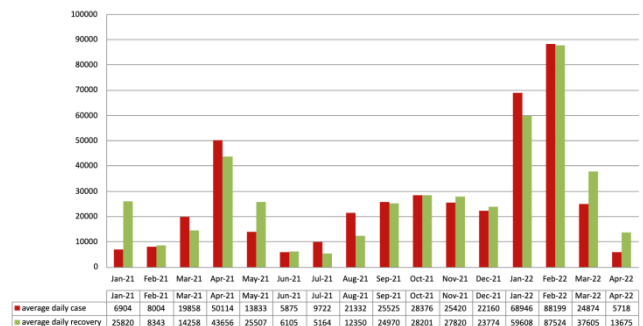


Fig. 1 Average monthly new case and average monthly recovery comparisons

Average daily cases and average daily recovery were almost parallel in the first six months of 2021 (Fig. 1). While daily recovery remains below daily cases in April, average daily cases are on the rise, and daily recovery is beginning to outpace daily cases in May. We noticed an upsurge in the

number of instances in the second half of 2021. Then, by the end of 2021, the quantity of daily recovery has increased. In 2022, daily cases average number 68.946 and peak with 88.199 in February. By the end of the first quarter of 2022, there are more average daily recoveries than average daily cases.

The first doses and daily recovery comparisons are shown in Fig.2. The first vaccination of individuals over the age of 90 began in January 2021. People over the age of 85 and those over the age of 80 in Turkey began getting vaccinations after a week later. People over the age of 75 started getting vaccinated after almost a month of the first vaccine. In May, the vaccination age was decreased to 40, and people from various professions such as law and tourism were vaccinated. Turkish citizens between the ages of 50 and 18 had their first vaccinations in June. In July, the age for receiving the first vaccination was reduced to 16, and in following months, the age for receiving the covid-19 vaccine was reduced to 12.

The second vaccination doses began in Turkey at the beginning of February (Fig 3). A two-week partial closure was scheduled to begin on April 14, 2021. Restrictions were placed as a consequence of an increase in the number of cases in several regions. In Turkey, we saw an increase in the number of second dose vaccines in the second half of 2021. End of 2021, we begin to witness an increase in the number of recoveries. During the year 2021, the majority of those who had been vaccinated received their second dose of vaccinations.

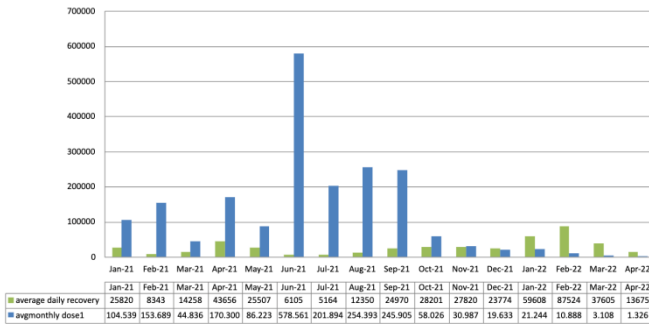


Fig. 2 Average first dose amounts and average recovery comparison

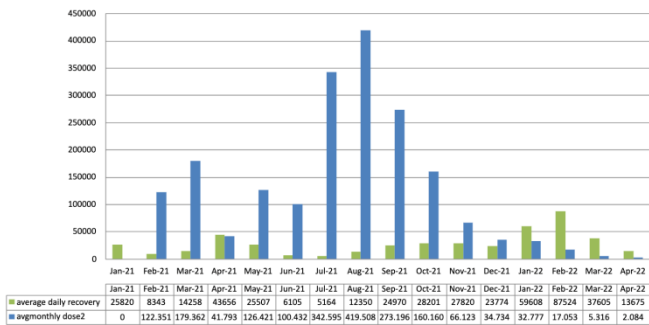


Fig. 3 Average second dose amounts and average recovery comparison

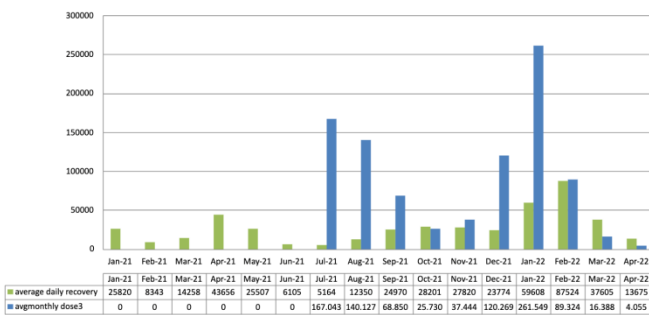


Fig. 4 Average third dose amounts and average recovery comparison

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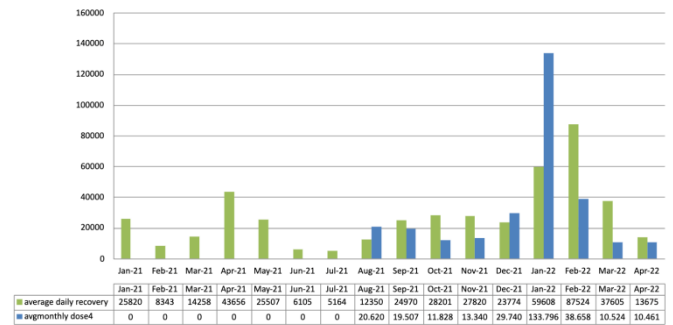


Fig. 5 Average fourth dose amounts and average recovery comparison

In the second half of 2021, those aged 50 and up, as well as healthcare workers who had already gotten two doses, received the third dose of vaccine. A complete shutdown was declared as the closure beginning on April 29, 2021 until May 17, 2021. Towards the end of 2021, December was the month in which the most people received their third round of vaccines (Fig. 4).

The fourth vaccination dosages began in Turkey on August 16, 2021. The reminder dosage application began in December 2021 for citizens who have gotten two doses of Sinovac and two doses of BioNTech vaccine and it has been three months after their previous vaccination. In January and February of 2022, we can notice a significant rise in average daily recovery (Fig. 5).

**B. Correlation Between Vaccination And Seriously Ill Case**

The seriously ill case is another important criteria because of the disease's life threatening effect. To see the possible effect of the vaccination doses, we visualized the obtained data in Fig. 6.

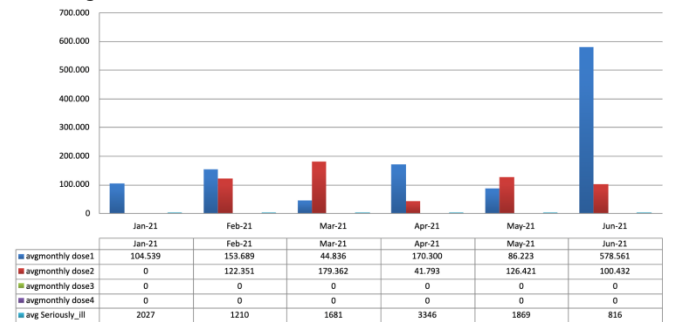


Fig. 6 Dose impacts for seriously ill case

Table 2. Vaccination Doses and Seriously Ill Cases

Methods	1.Doses	2.Doses
Kendall	-0.067	-0.2
Spearman	-0.2	-0.428
Pearson	-0.471	-0.476

In this stage, we had so limited data range for a valid detection. Because of the Ministry of Health of the Republic of Turkey's website stopped releasing statistics about seriously ill cases, Table 2 shows the vaccine doses and the number of seriously ill cases for only the first six months of 2021.

**IV. DISCUSSION**

The major goal of this research is to see if vaccination can help Turkey recover from the COVID-19 pandemic. This work were done based on Spearman, Kendall, and Pearson's

correlation utilizing data from the Ministry of Health of the Republic of Turkey to assess the first four doses of vaccine on patients. According to the obtained experimental results shows that vaccinations has a strong positive effect on recovery amounts (Table 1). However, because vaccines have a cumulative effect, we can't compare the effects of four doses independently. On the other hand, the vaccine's impact on the number of severe cases could not be widely researched. According to the information derived from the limited data obtained, it is seen that vaccination provides an weak-moderate amount decrease in the number of seriously ill patients.

## V. CONCLUSION

In this research, we are analysing whether vaccination can help coronavirus cases' recovery in Turkey. In addition, the research examined at the frequencies of severe disease during the vaccination phases. Using data from the Ministry of Health of the Republic of Turkey, the analyses are carried out using Spearman, Kendall, and Pearson's correlation. The findings revealed that there is a strong correlation between vaccination and recovery. The analysis of vaccination as separate doses on recovery rates is also included in this study. But we can't compare the effects of four doses independently since vaccines have a cumulative impact on disease.

The vaccine's effect on the disease has been difficult to measure due of the temporary quarantine. However, it is clearly seen in Table 1 that vaccination has a strong positive effect on recovery rates.

Additionally, we have proposed two datasets. The first of our datasets contains daily and total cases as well as the first four COVID-19 dosages, while the second contains the first two COVID-19 dosages as well as the monthly average number of seriously ill patients. The missing values of datasets were assumed to be 0 during the data preprocessing stage. The produced dataset is studied with the three correlation analysis techniques on the R Studio platform. The created datasets are publicly available on GitHub.

## ACKNOWLEDGMENT

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