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Analysis the Impact of COVID-19 Vaccine Doses on Daily Cases, Deaths, and Recoveries: A Statistical Analysis of Turkish Public Data

COVID-19 Aşı Dozlarının Günlük Vaka, Ölüm Ve İyileşmeler Üzerindeki Etkisinin İncelenmesi: Türk Kamu Verilerinin İstatistiksel Analizi

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ÖZ

Amaç: COVID-19 salgını tüm dünyayı etkilemiştir. Bu makale, Türkiye'de günlük Kovid-19 vakaları, ölüm ve iyileşmeler ile günlük COVID-19 aşıları arasındaki ilişkiyi ve aşı çalışmalarının etkinliğini araştırmayı amaçlamaktadır.
Araçlar ve Yöntem: Türkiye Cumhuriyeti Sağlık Bakanlığı verilerine dayanarak aşı dozları ile COVID-19 vakaları, ölüm sayısı ve iyileşen sayısı arasındaki ilişkinin araştırılması amaçlandı. Çalışmada, aşının ilk dozunun uygulandığı 13 Ocak 2021 ile günlük verilerin mevcut olduğu son tarih olan 31 Mayıs 2022 arasındaki dönem incelendi. Veriler Türkiye COVID-19 Pandemi İzleme Ekranı (TURCOVID19) platformundan elde edilmiştir. Toplam 504 günlük veriler analiz edildi.
Bulgular: Günlük ilk doz aşı sayısı 1.458.245, 2. doz aşı sayısı ise 912.226 olup, 1. ve 2. doz aşı sayısında yüksek değerler ortaya çıkmaktadır. Aşılama oranlarının yüksek olduğu dönemlerde günlük ölüm sayılarında azalma ve günlük iyileşme oranında artma görülmüştür. İyileşen vaka sayısı aşının 3. ve 4. dozlarının uygulanmasından sonra en yüksek seviyeye çıkmıştır.İki doz aşı aldıktan sonra enfekte olan kişi sayısının aşılanmayan enfekte kişi sayısına kıyasla önemli ölçüde azaldığı görülmüştür.
Sonuç: Dünya çapında ve Türkiye'de yapılan çeşitli çalışmalardan elde edilen sonuçlar, COVID-19 aşılarının hastalık yükünü azaltmadaki etkinliğini tutarlı bir şekilde ortaya koymaktadır.

Anahtar Kelimeler: aşı; COVID-19; Türkiye; ölüm oranı

ABSTRACT

Purpose: The COVID-19 epidemic has affected the entire world. This article aims to investigate the relationship between daily COVID-19 cases, deaths and recoveries, and daily COVID-19 vaccines in Turkey, and the effectiveness of vaccine studies.
Materials and Methods: Based on the data from the Ministry of Health of the Republic of Turkey, this study aims to investigate the relationship between vaccine doses and COVID-19 cases, deaths, and recoveries. The analysis covers the period from January 13, 2021, when the first dose of the vaccine was administered, to May 31, 2022, the most recent date for which daily data is available. The data were obtained from the Turkey COVID-19 Pandemic Monitoring Screen (TURCOVID19) platform, with a total of 504 days of data being analyzed.
Results: The daily number of first-dose vaccinations was 1,458,245, and the daily number of second-dose vaccinations was 912,226, with high values observed for both the first and second doses. During periods of high vaccination rates, a decrease in daily death counts and an increase in daily recovery rates were observed. The number of recovered cases reached its peak after the administration of the third and fourth doses of the vaccine. It was also observed that the number of individuals infected after receiving two doses of the vaccine was significantly lower compared to the number of infected individuals who were unvaccinated.
Conclusion: The results obtained from various studies conducted worldwide and in Turkey consistently demonstrate the effectiveness of COVID-19 vaccines in reducing the disease burden.

Keywords: COVID-19; death rate; Türkiye; vaccine

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INTRODUCTION

SARS-CoV-2 enters cells faster by attaching to ACE2 receptors.[1] COVID-19 symptoms vary from fever to shortness of breath.[2,3] This shows the need to understand the spread and impact of the virus in detail. RT-PCR and antigen tests are used for diagnosis, and serological tests are used to determine antibodies.[4] In the fight against COVID-19, Pfizer-BioNTech, Moderna's mRNA, AstraZeneca, Johnson & Johnson/Janssen's viral vector and Novavax's protein subunit vaccines have been developed.[5,6] These vaccines play an important role in reducing the spread and severity of the disease.

Studies have demonstrated the remarkable efficacy and effectiveness of COVID-19 vaccines in reducing the incidence of infection.[7] Clinical trials of several vaccines, such as the Pfizer-BioNTech mRNA vaccine and the Moderna mRNA-1273 vaccine, have shown high efficacy rates in preventing symptomatic COVID-19 cases.[5,8] Real-world studies support these findings, showing that vaccinated people are significantly less likely to contract the virus than unvaccinated people.[9,10] For example, a large-scale study conducted in Israel reported a significant reduction in COVID-19 cases among those vaccinated, demonstrating the efficacy of the Pfizer-BioNTech vaccine.[11]

COVID-19 vaccines have been shown to have a significant impact on reducing disease-related mortality. Several studies have shown a significant reduction in COVID-19 deaths following widespread vaccination. For example, a study analyzing the impact of vaccination campaigns in the UK found a significant reduction in COVID-19 mortality among vaccinated individuals, particularly in older age groups.[12,13,14] Research has shown that vaccinated individuals who experience sudden infection have milder symptoms and a lower risk of developing severe disease compared to unvaccinated individuals.[15] A study conducted in Spain concluded that vaccination in COVID-19 patients was associated with shortening the duration of the disease and reducing the likelihood of hospitalization.[16] Additionally, the relationship between vaccination rates and daily COVID-19 measurements at the population level has been examined in several studies. These studies show a strong inverse correlation between vaccination coverage and the incidence of COVID-19 cases in different countries.[17]

MATERIALS and METHODS

This study examines the relationship between vaccine doses and COVID-19 cases, deaths, and the number of recovered patients, using data from the Ministry of Health of the Republic of Turkey. The impact of vaccines on the pandemic has been evaluated by analyzing the correlation between vaccine doses and infection, death, and recovery rates. The aim is to understand the role of vaccines in the fight against COVID-19 and to contribute to pandemic management. The study covers the period between January 13, 2021, and May 31, 2022, and the data was obtained from the TURCOVID19 platform.[18,19] It was verified and corrected on the website of the Ministry of Health.[20] A total of 504 days of observation data were analyzed.

Most statistical procedures assume that data follows a normal or Gaussian distribution. This is especially true for parametric tests (correlation, regression, t-tests, and analysis of variance). The assumption of normality is particularly important when establishing reference ranges for variables. If these assumptions are invalid, it is difficult to draw accurate and reliable conclusions about reality. However, if the sample size is large enough (>30 or 40), violation of the normality assumption should not cause major problems. This means that parametric procedures can be used even with non-normally distributed data. If the skewness and kurtosis values exceed a certain threshold (absolute skewness greater than 3, kurtosis greater than 10), this may indicate more serious problems. Generally, large data sets show normally distributed results.

Descriptive statistics, correlation, ANOVA, and linear regression analyses were used to analyze the data. The analyses were carried out using the SPSS 25.0 package. The results obtained were evaluated according to the 95% confidence interval. Therefore, the results were considered significant if the p-value was less than 0.05.

Ethical statement: As no live data were used in our study and publicly available data were analyzed, it does not fall within the scope of articles requiring ethics committee approval.[23]

RESULTS

The daily number of first-dose vaccines is 1,458,245, the number of 2nd dose vaccines is 912,226, and high values are observed in the number of 1st and 2nd-dose vaccines. During this period, the daily number of deaths increased to 394. The daily number of cases was also the highest with 111.157.

The statistics and graphs of the daily number of cases, recoveries, and deaths, which are the dependent variables used in the study, and the daily doses of vaccine administered, which are the independent variables, are shown in Figure 1, Figure 2, and Figure 3, with the number of vaccines on the left and the number of cases on the right. The number of vaccines and the number of cases follow a close curve. The number of daily deaths also decreased during periods of high vaccination rates. The number of daily recoveries increases during periods of high vaccination rates. In particular, the number of recovered cases was highest after the administration of the 3rd and 4th doses of vaccine.

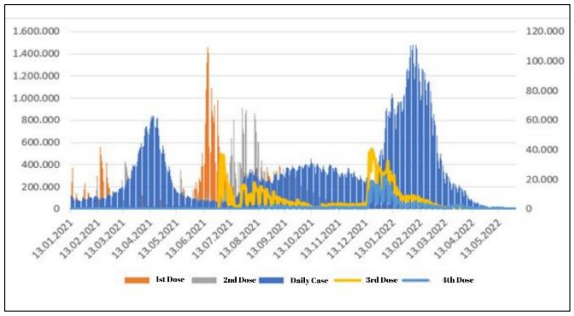

Figure 1. Daily number of cases and vaccination numbers.

The graph displays the number of vaccines on the left-hand side and the number of cases on the right-hand side. The relationship between vaccine doses and the number of cases is closely monitored.

When we look at the graph in Table 2, the numbers of vaccines are on the left side and the numbers of deaths are on the right side. It is observed that the number of daily deaths decreases in periods of high vaccination rates.

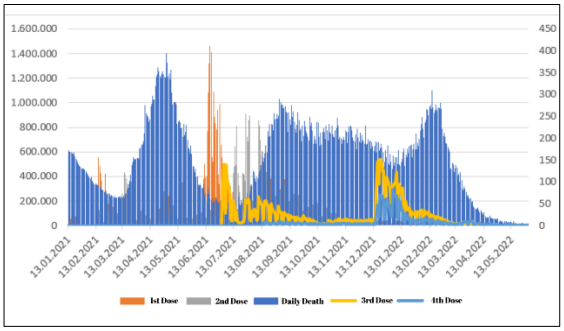

Figure 2. Daily number of cases and deaths.

In the graph, the number of vaccines is shown on the left side, and the number of recoveries is on the right side. It is observed that the number of daily recoveries increased during periods of high vaccination rates. Particularly after the administration of the 3rd and 4th vaccine doses, the number of recoveries reached its highest levels (Figure 3)

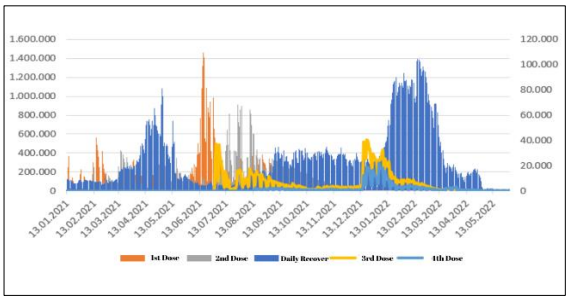

Figure 3. Daily number of cases and number of recovered.

It is seen that especially the 1st and 2nd dose vaccines sometimes reach very high numbers. The number of daily 1st dose vaccines reached as high as 1,458,245. Therefore, the kurtosis value is quite high.[21] Although the absolute value of Skewness greater than 3 and the value of Kurtosis greater than 10 may indicate a problem, values above 20 may indicate a more serious problem, it has been stated that this limit is not important if the number of observations is greater than 200.[22](Table 1 and Table 2)

When evaluating the results of the analyses presented in the table, the adjusted R2 value should be considered, as there is more than one independent variable in the regression model. This indicates the extent to which the independent variables can predict the change in the dependent variable. According to these results, the first

model has the greatest explanatory power. The lowest value belongs to the second model. The results of the ANOVA test and the model summary of the models are given in Table 3.

Table 1. Descriptive statistics.

Variables	Minimum	Maximum	Total	Standard Deviation (SD)	Skewness	Kurtosis
Daily Number of Cases	864	111.157	12.726.462	23797.01	1.611	2.181
Daily Number of Deaths	2	394	75.813	89.18	0.132	-0.754
Daily Number of Recovered	946	104.409	12.742.266	23807.12	1.551	1.726
Number of 1st dose vaccines per day	0	1.458.245	57.843.862	188023.80	3.569	17.088
Number of 2nd dose vaccines per day	0	912.226	53.067.793	148210.10	2.609	8.650
Number of 3rd dose vaccines per day	0	537.871	27.802.651	98391.78	2.657	7.346
Number of 4th dose vaccines per day	0	291.533	9.021.561	42207.37	4.164	18.359

Table 2. Correlation of variables in the models.

Variables		Number of 1st doses per day	Number of 2nd doses per day	Number of 3rd doses per day	Number of doses per day
Daily Number of Cases	Pearson Coefficient	-.211	-.117	.240	.334
	Probability (p)	.000	.009	.000	.000
Daily Number of Deaths	Pearson Coefficient	-.087	.028	.051	.097
	Probability (p)	.051	.524	.255	,029
Daily Number of Recovered	Pearson Coefficient	-.267	-.214	.113	.217
	Probability (p)	.000	.000	.011	.000

Table 3. ANOVA results and model summary.

Model	Model Summary			ANOVA	
	R	R^2	Adjusted R2	F	Probability
1 (Case)	.371	.137	.130	19.850	.000
2 (Death)	.150	.023	.015	2.890	.022
3 (Recovered)	.342	.117	.110	16.532	.000

Table 4. Coefficient table for variables in the model.

Model		Non-standardised coefficients		Standardise Coefficients	t	p
		Beta	S. Error	Beta		
1 (Number of cases)	(Constant)	24856.8	1404.2		17.702	.000**
	1st Dose Vaccine	-.019	.006	-.153	-3.441	.001**
	2nd Dose Vaccine	-.007	.008	-.042	-.840	.401
	3rd Dose Vaccine	.012	.018	.050	.664	.507
	4th dose vaccine	.149	.042	.264	3.566	.000**
2 (Number of Deaths)	(Constant)	147.2	5.601		26.285	.000**
	1st Dose Vaccine	$-4.2x10^{-5}$	.000	-.089	-1.884	.060
	2nd Dose Vaccine	$6.3x10^{-5}$	.000	.105	1.977	.049*
	3rd Dose Vaccine	$-9.7x10^{-5}$	.000	-.107	-1.348	.178
	4th dose vaccine	.000	.000	.178	2.260	.024*
3 (Number of Recovered)	(Constant)	28702.8	1421.2		20.196	.000**
	1st Dose Vaccine	-.025	.006	-.200	-4.455	.000**
	2nd Dose Vaccine	-.023	.008	-.146	-2.885	.004**
	3rd Dose Vaccine	.014	.018	.057	.758	.449
	4th dose vaccine	.067	.042	.119	1.583	.114

**p<0.01, *p<0.05

The beta coefficient (B) indicates the extent to which the independent variables in the model can predict the dependent variable. In the first model, the coefficients of the 1st and 4th vaccine doses were significant (t=-3.41, p=0.001<0.05 and t=3.57, p=0.001<0.05). The 1st dose of vaccine can explain a 2% decrease in the number of cases. The 4th vaccine dose seems to be associated with a 15% increase in the number of cases. The fact that this

period coincided with an increase in the number of cases due to variants led to this result. In the second model, the number of vaccine doses 2 and 4 was significant, but the signs of the coefficients were positive (t=1.98, p=0.049<0.05 and t=2.26, p=0.024<0.05). However, as the beta values are very small, it does not seem possible to speak of an effect. However, as mentioned above, this model has the lowest predictive power. In the third model, we see that the number of first and second doses is significant (t=-4.46, p=0.001<0.05 and t=-2.89, p=0.004<0.05). Although the beta coefficients are small, they are negative for both doses, i.e. the number of recoveries and the number of vaccinations were inversely proportional. A 1 unit increase in the number of vaccinations in the first dose was statistically associated with a 2.5% decrease in the number of recoveries and a 2.3% decrease in the number of vaccinations in the second dose. The coefficients of the variables in the model are shown in Table 4.

DISCUSSION

The results presented in this study emphasize the significant impact of COVID-19 vaccines on the daily number of cases, deaths, and recoveries. Findings from various studies, both globally and in Turkey, consistently demonstrate the effectiveness of COVID-19 vaccines in reducing the disease burden. These vaccines have proven effective in preventing infection, lowering mortality rates, and aiding in the recovery of COVID-19 patients.[16,17]

In a study by Bernal et al, it was observed that vaccine efficacy usually started within the first 7 days, increased up to 35 days and increased further after the second dose. This emphasizes the necessity of maintaining other precautions in the first week and the need for a second dose. This study also shows similar results. This study analyzed daily infection and hospitalization data by state in the United States between October 12, 2020, and March 7, 2021. The findings show that vaccinations significantly reduced the rate of increase in total COVID-19 cases and hospitalizations across the United States. One additional vaccine dose (at least one dose) given per 100 people reduces the total case increase rate by 0.7% and the increase rate in total hospitalizations by 0.7%. The effects of completing two doses of vaccine provide a greater reduction in the growth rate of total cases by 1.1% and hospitalizations by 1.1%. The results of the study strongly support that vaccinations have a significant reducing effect on COVID-19 cases and hospitalizations in the United States. The model, which examines vaccination trends between January and March 2021, predicts that herd immunity can be reached earlier if there are rapid vaccination rates and reduced vaccine hesitancy.[18] This study emphasizes that vaccinations are of critical importance for pandemic management and public health.[26] In our study, the number of 1st dose vaccination can explain a 2% decrease in the number of cases. The fact that the greatest explanatory power was in the first model, which is related to the number of cases per day, may have contributed to the greater reduction in the number of cases compared to the literature.

A study conducted in India observed that infection rates among individuals vaccinated against COVID-19 were significantly lower than those who were unvaccinated. Research results reveal that the number of people infected after receiving two doses of the vaccine is significantly reduced compared to the number of infected people who are not vaccinated. It was also determined that the increase in the number of infected people in the population directly led to an increase in the number of recoveries and deaths. This shows that the increase in the number of infected people and the increase in the number of recovered people is directly related to the increase in death rates. A decrease in the incidence of COVID-19 cases has been observed since the introduction of the vaccine. However, it is concluded that mass vaccination efforts must be continuously supported by personal protection measures and effective case management to significantly reduce the vulnerability of vaccinated individuals to reinfection and the prevalence of the disease in the population. These findings highlight the importance of vaccination and the need for a holistic approach to combating the epidemic.[22,24] Although the negative beta coefficients in our study support this situation, the recovery rate increased, and the number of COVID-19 cases decreased in regions where the vaccine was applied more. These results show that vaccination is effective and that vaccinating a large segment of the

population is an important factor in controlling the spread of the epidemic.

Results from studies conducted in Turkey showed high levels of efficacy for several COVID-19 vaccines. The Sinovac CoronaVac vaccine has shown significant efficacy in preventing infection in healthcare workers and the elderly. Similarly, the Pfizer-BioNTech vaccine is effective in preventing symptomatic and severe COVID-19 cases in different age groups. These results are consistent with global evidence on the efficacy of these vaccines.[24,25,26] Our study confirms that COVID-19 vaccines are effective in Turkey and are an important tool to control the spread of the disease. It also shows that different vaccines may be effective in different groups and that it is important to diversify vaccination programs.

The results of our research show that COVID-19 vaccines are effective in the number of daily cases, deaths, and recovered patients. Findings from similar studies conducted in Turkey confirm the positive effect of COVID-19 vaccines in line with global research. These data show that the vaccine plays a critical role in the fight against the pandemic and is an important factor in protecting public health. Research has reached these conclusions because of a detailed examination of the impact of vaccinations on cases, death, and recovery rates. These findings underscore the importance of expanding and continuing vaccination against COVID-19.

The Turkey COVID-19 Pandemic Monitoring Screen (TURCOVID19) platform, where the data is collected, does not provide information on age, gender, and chronic disease distributions. As a result, these factors could not be included in our study..

In this context, achieving high vaccination coverage is crucial for controlling the spread of the virus, minimizing the burden on health systems, and ultimately saving lives. Continued efforts are necessary to promote vaccination campaigns, improve vaccine coverage, and reduce vaccine hesitancy. Governments, health organizations, and communities must collaborate to ensure equitable access to vaccines and provide accurate information to the public, addressing concerns and misconceptions about vaccination

Conflict of Interest

The authors declare that there is not any conflict of interest regarding the publication of this manuscript.

Ethics Committee Permission

As no live data were used in our study and publicly availa-ble data were analyzed, it does not fall within the scope of articles requiring ethics committee approval.

Authors' Contributions

Concept/Design: EU, EŞ. Data Collection and/or Processing: EU, EŞ. Data analysis and interpretation: EU, EŞ. Literature Search: EU, EŞ. Drafting manuscript: EU, EŞ. Critical revision of manuscript: EU, EŞ.

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