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SHORT COMMUNICATION

Effectiveness of Inactivated and mRNA COVID-19 Vaccines Against SARS-CoV-2 Infection, Severe Disease and Mortality in the Geriatric Population

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Abstract

Older age (>60 years) has been identified as the main risk factor for COVID-19. In this study, we aimed to evaluate the efficacy of Pfizer–BioNTech and CoronaVac vaccines against COVID-19 infection, serious illness, and mortality in the geriatric population. We found that 2 doses of CoronaVac vaccine were ineffective in protecting against COVID-19 infection in people over 65 years of age, while the vaccine efficacy (VE) of the mRNA vaccine against COVID-19 was 80% (95% CI 70–87). The VE of full vaccination with BioNTech was 89% (95% CI 53–97) against hospitalization, 79% (95% CI 0–97) against death, and 79% (95% CI 0–97) against intensive care unit (ICU) admission. However, the VE of full vaccination with CoronaVac was 50% (95% CI 33–63) against hospitalization, 53% (95% CI 26–70) against ICU admission, and 56% (95% CI 30–73) against death. In conclusion, we found that the mRNA vaccine has higher efficacy against severe COVID-19 infection and mortality in the geriatric population than the inactivated vaccine. Booster doses of vaccines should be considered in increasing the effectiveness of inactivated vaccines. Given the potential of SARS-CoV-2 mutations evading vaccination protection and the risk of reduced immunity over time, regular monitoring of vaccine effectiveness in the real world is critical.

Introduction

A new type of coronavirus, namely Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) has caused the pandemic of coronavirus disease 2019 (COVID-19) from December 2020 [1]. COVID-19 disease manifests itself clinically in a variety of ways, ranging from asymptomatic, mild symptoms to acute respiratory distress syndrome (ARDS) and death [2, 3]. Worldwide, approximately 764.5 million cases and 6.9 million deaths related to COVID-19 have been confirmed and 13.325 billion doses of the vaccine have been administered so far [4]. During this period, a total of 17.232.066 people were infected in Turkey and 102.174 of them died [5].

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The main risk factor for COVID-19 is identified as older age (60+ years) [6, 7]. In addition, elderly and immunocompromised individuals with comorbidities like diabetes, hypertension, cancer, asthma, and cardiovascular abnormalities are more severely affected, with a higher case fatality rate [8]. The mortality rate of COVID-19 has been reported to be 1–3%, and this rate has been found to be higher in elderly patients, especially in men [9, 10]. Several main processes of aging may interfere with the course of SARS-CoV-2 infection and affect the prognosis of the disease [11]. Among these phenomena, cellular senescence, both in the field of the immune system and in the respiratory epithelium and vascular endothelium, appears to be particularly important as it can affect the course of SARS-CoV-2 infection [12]. Therefore, vaccination of elderly individuals should be prioritized if there are no contraindications [13].

Immunization against COVID-19 via vaccines will not only prevent the virus's spread but will also limit the pandemic's serious health consequences [14]. On various vaccine platforms (mRNA, viral vector, protein/peptide, and inactivated virus), comparisons have been performed on the relationship between efficacy and neutralizing and binding antibody titers in vitro [15, 16]. For the prevention of COVID-19 in individuals aged 16 and older,

the US Food and Drug Administration (FDA) issued an emergency use authorization for the BNT162b2 COVID-19 vaccine (Pfizer-BioNTech, mRNA-based COVID-19 vaccine, Germany) on December 11, 2020 [17]. Vaccination with BNT162b2 (Pfizer–BioNTech) has been shown to be successful in reducing the risk of death and COVID-19-related admissions in a nationwide vaccination program in Israel [18]. According to the World Health Organization (WHO), more than 100 vaccines have been developed as of this writing, 33 vaccines have been evaluated in phase III clinical trials, and 10 vaccines have reached the phase IV clinical stage [19]. Efficacy ranging from 60 to 94% were reported for various vaccines, but head-to-head comparisons between different vaccine platforms are not possible because of differences in trial design, measured endpoint, trial location, population studied, and prevalence of SARS-CoV-2 variants during trial [6].

CoronaVac vaccine, developed by Sinovac Life Sciences (Beijing, China), boosts immune response to all SARS-CoV-2 viral proteins, including matrix, envelope, nucleoprotein structures, and spike protein, using a traditional inactivation technique [20]. In the phase 3 study, efficacy rates remained high, although they ranged from 19 to 51% by countries [21, 22]. Vaccines based on mRNA and adenovirus vectors have been shown to be effective against COVID-19 in the elderly. However, there is limited evidence for the efficacy of inactivated vaccines in this population [23–26]. CoronaVac was approved for use by the World Health Organization's Emergency Use List procedure in early June 2021, but a gap has been identified in the evidence for its effectiveness in adults aged ≥60 years [24].

CoronaVac (Sinovac Biotech) has been approved for use by 32 countries and states, and the COVID-19 outbreak continues as a result of the emergence of worrying SARS-CoV-2 variants in many of these countries [27]. The Ministry of Health in Turkey approved the use of CoronaVac (Sinovac) on January 13, 2021 and first started the vaccination in healthcare workers. On February 12, 2021, the geriatric population over the age of 65 started to be vaccinated. In Turkey, vaccination with the BNT162b2 vaccine began in April 2021. Vaccines from Pfizer-BioNTech and CoronaVac are currently being administered in Siirt Province. Individuals over the age of 65 were among the first to be vaccinated against COVID-19. However, data on the efficacy of the vaccines in this population are still limited. In the current study, we aimed to evaluate the efficacy of Pfizer–BioNTech and CoronaVac vaccines against COVID-19 infection, serious illness (hospitalization, need for intensive care), and mortality in the geriatric population in the delta variant-predominant period.

Materials and Methods

In the current study, the COVID-19 vaccination status of 6168 people from the geriatric population aged 65 and over residing in Siirt Province, and the cases of contracting COVID-19 during the period between 1 July and 15 September 2021, when the SARS CoV-2 delta variant was dominant, were retrospectively examined. Furthermore, the clinical course of the disease in COVID-19 patients was investigated. The geriatric population's vaccination status was assessed using three groups: two doses of BioNTech vaccine (827), two doses of CoronaVac vaccine (2239), and unvaccinated (3102). Vaccine protection was considered to have started when at least 14 days had passed since the last dose of the vaccine. The study excluded anyone who had COVID-19 in the 6 months prior to July 1, 2021. As the positive control group, people aged 65 and over who had positive COVID-19 PCR test between 1 July and 15 September 2021 were included in the study. As the negative control, persons aged ≥65 years without COVID-19 PCR test positivity during the 2.5-month follow-up period of our study were selected. The information about the inpatients in our study was accessed from the hospital information management system. Geriatric patients with a positive COVID-19 PCR test result 14 days prior to hospital admission or up to three days after admission were included in the study. In the deaths caused by COVID-19 detected in our study, a positive test result was detected within 30 days before death or within seven days after death.

The list of geriatric populations with 2 doses of BioNTech vaccine, 2 doses of CoronaVac vaccine, and unvaccinated was accessed from the Republic of Turkey Ministry of Health Public Health Management System. Vaccination information of ex-patients was obtained from the files of the patients. Detection of SARS-CoV-2 in nasopharyngeal and oropharyngeal samples by Reverse Transcriptase Polymerase Chain Reaction (RT-PCR) was performed as previously described by Özüdoğru et al. [28]. Blood values including C-reactive protein (CRP) lymphocyte level, Ferritin level, and D-dimer level were measured according to Özüdoğru et al. [28].

The Statistical Package for the Social Sciences (SPSS) 26.0 statistical program was used to analyze the data. In categorical variables, data is presented as descriptive statistics, number of cases, and percentage. The Kolmogorov–Smirnov Goodness of Fit Test was used to determine normality in the analysis of continuous variables. The ANOVA test was used to compare normally distributed data, and the Kruskal-Walli's test was used to compare data not shown. The Chi-Square Test was used to compare categorical data. The means were shown along with

their standard deviations. $P < 0.05$ was used to determine statistical significance. The outcome data (vaccine effectiveness) are expressed as a rate difference, with the odds ratio (OR) for infection despite vaccination being used: $= (1 - \text{OR}) \times 100 = \text{Effectiveness}$. The Confidence Interval (CI) for vaccine efficacy (VE) was chosen as 95%. Calculations were made with StatGraphics18 software.

Results

A total of 6168 people over the age of 65 were included in our study, including 2406 (39%) men and 3762 (61%) women. The mean age of men was 74.4 ± 7.5, and the mean age of women was 75.7 ± 8.3. In our study, 827 (13.4%) of geriatric patients were vaccinated with two doses of BioNTech, 2239 (36.3%) were vaccinated with two doses of CoronaVac, and 3102 (50.3%) were unvaccinated. Table 1 shows the rates of Covid-19 transmission in the Delta variant predominant period according to the vaccination status of geriatric population. As seen in the Table 1, 24 (2.9%) of 827 people vaccinated with 2 doses of BioNTech, 347 (15.5%) of 2239 people vaccinated with 2 doses of CoronaVac, and 403 (13.0%) of 3102 unvaccinated people had COVID-19. The difference between these rates between the vaccine groups was significant ($P < 0.05$). The lowest rate of COVID-19 was detected in the group with 2 doses of BioNTech vaccine (Table 1). The VE of the mRNA vaccine against COVID-19 was found to be 80% (95% CI 70–87). The two-dose CoronaVac vaccine was found to be ineffective in protecting against COVID-19 infection. Number of people, mean age, gender ratios and mean age of genders among vaccine groups are given in Table 2. It was determined that 13.4% of 6168 geriatric patients in our study were vaccinated with 2 doses of BioNTech, 36.3% were vaccinated with 2 doses of CoronaVac, and 50.3% were unvaccinated. The mean ages of these vaccine groups were 72.0 ± 5.8, 76.1 ± 8.2 and 75.5 ± 8.2, respectively. In the vaccinated groups, the number of women and their mean age were higher than men. As shown in Table 2, there was a significant difference in the number of people, mean age, gender ratios, and mean age of the sexes between the vaccine groups ($P < 0.05$).

In our study, 288 (37.2%) of 774 geriatric patients who had COVID-19 were hospitalized. When hospitalization rates were examined, only 2 (8.3%) of those who received 2 doses of BioNTech required hospitalization, while 102 (29.4%) of those who received 2 doses of CoronoVac required hospitalization. In addition, 184 (45.7%) of the unvaccinated patients required hospitalization. When the hospitalization rates in the intensive care unit (ICU) were compared, only 1 (4.2%) person who received 2 doses of BioNTech and 30 (8.6%) people who received 2 doses of CoronaVac were treated in the intensive care unit, while 68 (16.9%) people who were not vaccinated were treated in the

Table 1 The rates of Covid-19 transmission in the Delta variant predominant period according to the vaccination status of geriatric population

Vaccination status	No Covid-19 (n = 5394)		Have had Covid-19 (n = 774)		Test	*P*
	n	%	n	%		
2 dose BioNTech	803	97.1	24	2.9	chi-square	0.000
2 dose CoronaVac	1892	84.5	347	15.5		
Unvaccinated	2699	87.0	403	13.0		

Table 2 Number of people, mean age, gender ratios and mean age of genders among vaccine groups

	2 dose BioNTech		2 dose CoronaVac		Unvaccinated		Test	*P**
	N	%	N	%	n	%		
Number of persons	827	13.4	2239	36.3	3102	50.3	chi-square	0.000
Gender								
Male	403	48.7	898	40.1	1105	35.6	chi-square	0.000
Female	424	51.3	1341	59.9	1997	64.4		
	Mean	Median	Mean	Median	Mean	Median	Test	*P**
Mean of age	72.0 ± 5.8	71.0	76.1 ± 8.2	75.0	75.5 ± 8.2	74.0	Kruskal–Wallis	0.000
Mean of age								
Male	71.6 ± 5.9	71.0	75.0 ± 7.7	73.0	75.0 ± 7.7	73.0	Kruskal–Wallis	0.000
Female	72.3 ± 5.8	71.0	76.8 ± 8.5	76.0	75.7 ± 8.5	74.0	Kruskal–Wallis	0.000

*$P < 0.05$ significant relationship, $P > 0.05$ no significant relationship

Table 3 Hospitalization rates and mean days of hospitalization of those who had COVID-19

	2 dose BioNTech		2 dose CoronaVac		Unvaccinated		Total		Test
	n	%	n	%	n	%	n	%	*P*
Hospitalization									
Yes	2	8.3	102	29.4	184	45.7	288	37.2	chi-square 0.000
No	22	91.7	245	70.6	219	54.3	486	62.8	
Intensive care									
Yes	1	4.2	30	8.6	68	16.9	99	12.8	chi-square 0.002
No	23	95.8	317	91.4	335	83.1	675	87.2	
Ex									
Yes	1	4.2	27	7.8	65	16.1	93	1.0	chi-square 0.001
No	23	95.8	320	92.2	338	83.9	681	88.0	
Mean of hospitalization day[a]	6.0 ± 7.1	6.0	9.5 ± 6.0	8.0	11.0 ± 7.5	9.0	10.4 ± 7.0	9.0	Kruskal–Wallis 0.241

[a]In the measurement data, mean ± standard deviation was calculated instead of n, and median values were calculated instead of %

Table 4 Effectiveness of inactivated and mRNA vaccines against severe disease and mortality in the delta variant predominant period in the geriatric population

Outcome	Vaccination status	VE (95% CI), %
Hospitalization	2 dose BioNTech	89 (53–97)
	2 dose CoronaVac	50 (33–63)
Intensive care	2 dose BioNTech	79 (0–97)
	2 dose CoronaVac	53 (26–70)
Mortality	2 dose BioNTech	77 (0–97)
	2 dose CoronaVac	56 (30–73)

ICU. Among the 774 COVID-19 patients in our study, 1 (4.2%) patient who received 2 doses of BioNTech, 27 (7.8%) patients who received 2 doses of CoronaVac, and 65 (16.1%) patients who were unvaccinated died. The total number of patients who died was 93 (12%). When the hospitalization, intensive care and mortality rates of the patients with COVID-19 in the vaccine groups were compared, a statistically significant difference was found ($P < 0.05$), while no significant difference was found in the mean days of hospitalization ($P > 0.05$) (Table 3).

Table 4 presents effectiveness of inactivated and mRNA vaccines against severe disease and mortality in the delta variant predominant period in the geriatric population. The efficacy of full vaccination with CoronaVac was found as 50% (95% CI 33–63) against hospitalization, 53% (95% CI 26–70) against ICU admission, and 56% (95% CI 30–73) against death. In addition, the efficacy of full vaccination with BioNTech was found as 89% (95% CI 53–97) against hospitalization, 79% (95% CI 0–97) against ICU admission, and 77% (95% CI 0–97) against death.

From COVID-19 patients admitted to our hospital, computed tomography (CT) scan is performed to detect lung involvement using Ministry of Health algorithms. Additionally, blood values such as CRP, lymphocyte, ferritin, and D-dimer are requested to provide prognostic information. In our study, CT reports and blood values of 288 hospitalized geriatric COVID-19 patients were analyzed and vaccination status was compared between groups. As seen in Table 5, there was no significant difference between the vaccine groups in terms of CRP, lymphocyte, D-dimer and ferritin values used as prognostic factors ($P > 0.05$).

The severity of lung involvement of hospitalized COVID-19 patients was compared using oxygen support status

Table 5 Comparison of the prognostic blood values of those who had COVID-19 in the delta variant dominant period

	2 dose BioNTech (N = 2)			2 dose CoronaVac (N = 102)			Unvaccinated (N = 184)			Test	*P**
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max		
CRP	133.2 ± 0.3	133.0	133.0	99.6 ± 43.4	4.0	151.0	96.9 ± 38.5	6.0	152.0	Kruskal–Wallis	0.243
Lymphocyte	1.0 ± 1.1	0.3	1.8	0.8 ± 0.9	0.0	8.4	0.7 ± 0.7	0.0	6.6	Kruskal–Wallis	0.672
Ferritin	963.1 ± 971.5	276.0	1650.0	578.1 ± 492.3	20.0	1650.0	726.5 ± 556.4	27.0	1650.0	Kruskal–Wallis	0.081
D-dimer	4845.0 ± 5754.4	776.0	8914.0	2055.4 ± 2153.7	261.0	10,000.0	2758.5 ± 2896.3	354.0	11,200.0	Kruskal–Wallis	0.086

*$P < 0.05$ significant relationship, $P > 0.05$ no significant relationship

and CT involvement rates. All of the inpatient COVID-19 patients in our study needed oxygen support and there was involvement in lung CT reports. Of the 2 people who received 2 doses of BioNTech and were hospitalized, 1 received Hi-flow, and 1 received oxygen support with mechanical ventilation (MV). When the CT involvement of these 2 people was examined, it was determined that one had moderate and the other had severe involvement. Since these values were small in the population with 2 doses of BioNTech vaccine, they could not be included in the statistical study. Of the 102 inpatients who received 2 doses of CoronaVac vaccine, 10 (9.8%) received CIPAP, 14 (13.7%) Hi-flow, 27 (26.5) MV, and 51 (50.0%) nasal oxygen support. Of 184 unvaccinated hospitalized patients, 31 (16.8%) received CIPAP, 29 (15.8%) Hi-flow, 58 (31.5%) MV, and 66 (35.9%) nasal oxygen support. There was no significant difference between the oxygen support status of the 2 doses of CoronaVac vaccine and the unvaccinated group ($P=0.101$). In the CT reports of patients who received 2 doses of CoronaVac vaccine, mild involvement was seen in 51 (50.0%), moderate involvement in 14 (13.7%), and severe involvement in 37 (36.3%) patients. In the CT reports of unvaccinated patients, mild involvement was seen in 63 (34.2%), moderate involvement in 32 (17.4%), and severe involvement in 89 (48.4%) patients (Table 6). As seen in Table 6, when these two groups were compared, it was found that the CT uptake of the unvaccinated patients was worse, and this difference was statistically significant ($P=0.034$).

Discussion

Administration of vaccines against SARS-CoV-2 is an important asset in slowing the 2019 coronavirus disease COVID-19 pandemic [29]. By early 2021, multiple types of vaccines had been approved in many jurisdictions. Some of these were developed using full virus inactivation technology and have received partial or full approval in China and many other countries [30, 31].

As of October 2021, CoronaVac (Sinovac) and HB02 (Sinopharm) inactivated vaccines accounted for nearly half of all COVID-19 vaccines distributed globally [32]. BNT162 is an mRNA-based vaccine developed by Pfizer and BioNTech. The vaccine's primary outcome was reported to be 95% effective in preventing mild to severe cases of COVID-19 in the general population, and 94% effective in adults over 65 years of age without serious safety concerns [33]. High-income countries preferentially have implemented mRNA-based vaccines, while low- and middle-income countries have used vaccines based on viral vectors or inactivated virus technologies [34].

Adults aged 65 and over are at high risk for serious consequences of COVID-19 and have been identified as the priority group for receiving the first COVID-19 vaccines approved for use under the Emergency Use Authorization in the United States [35]. Clinical trials suggest high efficacy for COVID-19 vaccines, but there is a need for evaluation of vaccine efficacy in real-world settings and against serious consequences in high-risk populations, including older adults [36]. Following the global transmission of the delta (B.1.617.2) variant in June and July 2021, reports of reduced efficacy of the BNT162b2 and other COVID-19 vaccines against SARS-CoV-2 infections caused by the delta variant began to surface [37]. After full immunization, the efficacy of mRNA vaccines against symptomatic COVID-19 was reported as 47.3–88% against delta [29]. In a study conducted in a large integrated health care system in the USA, the VE of 2 doses of BNT162b2 against infection was found as 91% (95% CI 88–93) for those aged 12–15 years, and 61% (57–93 years) for those aged 65 and over [37]. The overall efficacy of 2 doses of BNT162b2 against infection with the delta variant was found as 75% (95% CI 71–78), while

Table 6 Oxygen support status and computed tomography (CT) uptake rates of those who had COVID-19 in the delta variant dominant period

	2 dose BioNTech**		2 dose CoronaVac		Unvaccinated		Total		Test	*P**
	n	%	n	%	n	%	n	%		
Oxygen demand										
CİPAP	0	0	10	9.8	31	16.8	41	14.3	chi-square	0.101
HI-flow	1	50	14	13.7	29	15.8	43	15.0		
MV	1	50	27	26.5	58	31.5	85	29.7		
Nasal	0	0	51	50.0	66	35.9	117	40.9		
CT										
Mild	0	0	51	50.0	63	34.2	114	39.9	chi-square	0.034
Moderate	1	50	14	13.7	32	17.4	46	16.1		
Serious	1	50	37	36.3	89	48.4	126	44.1		

*$P<0.05$ significant relationship, $P>0.05$ no significant relationship

**Because the values were small, they were not included in the statistical study

the overall VE for other variants was found as 91%. In the same study, VE for 2 doses of BNT162b2 versus hospitalization was reported as 93% (95% CI 84–96) for delta and 95% (90–98) for other variants [37]. In a study investigating the efficacy of full two-dose mRNA-based (BNT162b2 or mRNA-1273) vaccination among adults 50 years of age or older, vaccine efficacy against confirmed SARS-CoV-2 infection leading to hospitalization was reported as 89% (95% CI 87–91). In the study, the efficacy of the BNT162b2 vaccine in adults over 50 years of age in preventing hospitalization was found as 87% (85–90), the efficacy of mRNA vaccines in preventing symptomatic disease was found as 91% (89–93), and the efficacy in preventing intensive care hospitalization was found as 90% (95% CI 86–93) [38]. In a study investigating the efficacy of mRNA-based (BNT162b2 or mRNA-1273) COVID-19 vaccines, vaccine efficacy against symptomatic infection ≥7 days after two doses was reported as 91% (89% to 93%), and vaccine efficacy against serious outcomes such as hospitalization or death was reported as 98% (88% to 100%). In subgroup analysis, lower vaccine efficacy against symptomatic infection was found in adults aged ≥70 years and with comorbidities [39]. In a study that calculated the efficacy of the mRNA-1273 COVID-19 vaccine (Moderna) and BNT162b2 vaccines among US veterans, the vaccines were not evaluated separately [40]. In this study, 1 dose was considered as partially vaccinated and 2 doses as fully vaccinated. In the general population, adjusted vaccine efficacy against COVID-19 for full vaccination was 95% (95% CI 93–96%) and vaccine efficacy against hospitalization was 91% for fully vaccinated (95% CI 83–95%). In veterans older than 65 years (3,350,373 veterans [50%], ≥65 years), the adjusted vaccine efficacy against COVID-19 for full vaccination was reported as 94% (93% CI 90–95%). In the same study, there was no death among veterans who were fully vaccinated [40]. In another study conducted in the USA, the effectiveness of full vaccination in preventing hospitalization among adults aged 65–74 was found to be 96% (95% CI 94–98%) for Pfizer-BioNTech [41]. In a study conducted among nursing home residents, mostly elderly individuals, the adjusted VE against infection among those who were fully vaccinated during the delta period was 52.4% for Pfizer-BioNTech [42]. In a multi-state analysis of adults 65 years and older who received BNT162b2 or mRNA-1273, vaccine efficacy against hospitalization for COVID-19 was reported as 95% after two doses [36]. In our study, the efficacy of 2 doses of mRNA (Pfizer-BioNTech) vaccine against COVID-19 infections in the geriatric (≥65 years old) population in the delta variant-predominant period was 80% (95% CI 70–87), VE against hospitalization was 89% (%) 95 CI 53–97), VE against ICU admission was 79% (95% CI 0–97), and VE against death was 77% (95% CI 0–97).

There is a limitation of real-world evidence for inactivated COVID-19 vaccines against the highly infectious B.1.617.2 (Delta) variant of SARS-CoV-2 [43]. In a study looking at the efficacy of two doses of CoronaVac vaccine in individuals aged over 70 years during the gamma variant-related epidemic in Brazil, adjusted vaccine efficacy against symptomatic COVID-19 ≥14 days after the second dose was reported as 47%, adjusted VE against hospitalization was reported as 56%, and VE against deaths was reported as 61% [27]. According to another study, CoronaVac was found to be very effective against hospitalization (87.5%) and death (86.3%) after full immunization [23]. In a study investigating the efficacy of CoronaVac and HB02 inactivated vaccines, it was reported that 1.3% of 10 805 participants contracted COVID-19, 1.2% developed a symptomatic infection, 1.1% had pneumonia, and 0.2% had a serious or critical illness. It was reported that adjusted VEs for full vaccination were 51.8% (95% CI 20.3–83.2) against infection, 60.4% against symptomatic infection (CI 31.8–88.9), and 78.4% (CI 56.9—99.9) against pneumonia. Also, full vaccination was found to be 100% effective against severe or critical illness (CI 98.4–100.0) [43]. In another study, Cerqueira-Silva et al. [34] reported that the vaccine efficacy of complete vaccination with CoronaVac was 53.2% (95% CI 52.4–54.1) against COVID-19, 71.2% (95% CI 70.0–72.4) against hospitalization, 72.2% (95% CI 70.2–74.0) against hospitalization in the ICU, and 73.7% (95% CI 72.1–75.2) against death. Again, in their study, it was reported that the VE of CoronaVac reached approximately 75% protection in individuals ≤79 years of age, 63.5% in individuals aged 80–89 years, and 48.6% in individuals over 90 years of age. In our study, the VE of complete vaccination with 2 doses of CoronaVac in the delta variant-predominant geriatric population (≥65 years) was 50% (95% CI 33–63) against hospitalization, 53% (95% CI 26–70) against ICU admission, and 56% (95% CI 30–73) against death. Variability in estimates of VE between studies may be due to differences in the study population, SARS-CoV-2 testing practices and diagnoses, varying follow-up times, different dose ranges, the prevalence of immunosuppressive risk factors, the prevalence of previous infections, analytical methods, and circulating virus variant strains. In case–control studies, vaccinated people may be more likely to seek healthcare and SARS-CoV-2 testing, resulting in a reduction in efficacy estimate [29]. In addition, in our study, it was found that 2 doses of CoronaVac vaccine were ineffective in protecting against COVID-19 infection in people over 65 years of age. In a phase 4, non-inferiority single-blind, randomized study in Brazil, Antibody concentrations was reported to be low 6 months after previous immunization with two doses of CoronaVac [44]. They reported that a heterologous dose of a third vaccine with recombinant adenoviral vector, an mRNA vaccine, or a vaccine with a recombinant adenoviral vector caused a significant increase in binding and

neutralizing antibodies against both delta and omicron variants, which could increase protection against infection, and the highest antibody concentrations was found after an mRNA boost (BNT162b2, Pfizer–BioNTech). Another study in Malaysia reported similar results [45]. A recent study in Pakistan [46] reported that inactivated vaccines (BBIBP-CorV and CoronaVac) were ineffective against COVID-19 infections ≥14 days after receiving the first dose, and the vaccines showed moderate efficacy against COVID-19 infections and symptomatic COVID-19 infections ≥14 days after the second dose [VE: %36 (%95 CI 10, 54; $P=0.009$)].

Elderly patients are expected to have a higher incidence of severe disease and mortality with the need for ICU admission [47]. In our study, 288 (37.2%) of 774 geriatric patients who had COVID-19 in the delta variant dominant period were hospitalized. When hospitalization rates were examined, 2 (8.3%) of those who received 2 doses of BioNTech, 102 (29.4%) of those who received 2 doses of CoronaVac, and 184 (45.7%) of those who were not vaccinated required hospitalization. When the hospitalization rates in the intensive care unit were compared, 1 (4.2%) person who received 2 doses of BioNTech, 30 (8.6%) people who received 2 doses of CoronaVac, and 68 (16.9%) people who were not vaccinated were treated in the ICU. Out of 774 COVID-19 patients in our study, 1 (4.2%) person with 2 doses of BioNTech, 27 (7.8%) people with 2 doses of CoronaVac, and 65 (16.1%) people who were not vaccinated, a total of 93 (12.0%) people died. When the hospitalization, intensive care and ex rates of the patients with COVID-19 in the vaccine groups were compared, a statistically significant difference was found ($P<0.05$), but no significant difference was found in the mean hospitalization days ($P>0.05$).

Early reports identified lymphopenia and elevations of D-dimer, ferritin, interleukin 6 (IL-6), troponin and myoglobin, CRP, and lactate dehydrogenase (LDH) as predictive biomarkers for the clinical outcome of hospitalized patients [28, 48]. Studies have been conducted that observed an increase in LDH, D-dimer, and CRP levels and a decrease in platelet count in elderly COVID-19 patients [49, 50]. Severe lymphocytopenia (800 cells/L) is the most common laboratory hematological finding in critically ill COVID-19 patients [8]. In our study, no statistically significant differences in blood values, which are considered prognostic factors in geriatric COVID-19 patients who were hospitalized, were found between the vaccine groups ($P>0.05$).

Oxygen therapy is recommended by the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) as the first-line therapy for respiratory distress and hypoxia caused by COVID-19. In our study, no significant difference was found between the oxygen support status of the 2 doses of the CoronaVac vaccine and the unvaccinated group ($P=0.101$). When these two groups were compared, it was found that the CT involvement of the unvaccinated patients was worse, and this difference was statistically significant ($P=0.034$).

Our study has some limitations. First, we could not distinguish the independent effect of the Delta variant from other factors, such as potential reduction of vaccine-induced immunity. Second, in our study, we were unable to control for potential confounding factors, such as the presence of underlying health conditions or the effect of previous SARS-CoV-2 infections on VE. Finally, vaccination dates were not available and the time elapsed since vaccination (to 1 July 2021) could not be measured to assess potential reduction of protection.

Conclusion

In conclusion, the efficacy of mRNA vaccine against serious COVID-19 infection and mortality in the geriatric population in our study was found to be higher than the inactivated vaccine. Given the risk of the emergence of SARS-CoV-2 variants that may evade the protective effect of vaccines and the risk of decreased immunity over time, continuous monitoring of the real-world effectiveness of vaccines is important. Booster doses are needed to restore the high levels of protection observed early in the vaccination program.

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Availability of Data and Materials The datasets that support the findings of this study are included in the paper. Any additional questions should be directed to the corresponding author. Data is available upon request.

Code Availability Not applicable.

Declarations

Conflict of interest The authors declare no conflict of interest.

Consent to Participate In our country, Covid-19 vaccines are made voluntarily and with signature. We used the data with the permission of the hospital and the Ministry of Health and obtained the permission of the ethics committee.

Consent for Publication Not applicable.

Ethics Approval This study was approved by the Siirt University Non-Interventional Clinical Research Ethics Committee in compliance with Helsinki (Decision Date: 11.09.2021, Number: 20631).

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