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Comparing the effectiveness of different vaccination regimens using Sinovac and BNT162b2 vaccines among hospitalised patients: A single-centre hospital-based retrospective cohort study

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ABSTRACT

Objectives: This study aimed to assess the effectiveness of different vaccination regimens using two distinct SARS-CoV-2 vaccines against mortality risk and the need for intensive care unit (ICU) admission among hospitalised patients.

Methods: The single-centre hospital-based retrospective cohort study was performed with adult COVID-19 patients in a tertiary-level hospital between March 2020 and September 2022. The associations between patients' demographics and clinical features, vaccine status and regimens, in-hospital mortality, and need for ICU admission were evaluated using multivariable regression analyses.

Results: During the study period, 2,373 patients were included. Mortality among unvaccinated patients was 85.0%, which was significantly lower in vaccinated groups (P<0.001), particularly with BNT162b2 than with Sinovac. Vaccination reduced mortality and ICU admission rates, with higher efficacy observed with increased vaccine doses and BNT162b2 regimens. Multivariable analyses confirmed age as a significant determinant and various vaccination schedules showed consistent reductions in mortality and ICU admissions.

Conclusions: A two-dose initial plus one or more-dose booster BNT162b2 regimen effectively reduced mortality risks and ICU admission.

Keywords: COVID-19, vaccine, mortality, intensive care unit

SARS-CoV-2 infection (COVID-19) is characterised by a respiratory syndrome that can vary in severity, ranging from mild effects to life-threatening consequences. Its fatality rate is approximately 2.3%, lower than SARS-CoV and MERS-CoV infections [1]. It is noteworthy that COVID-19 has caused significantly more deaths globally because SARS-CoV-2 is widely transmitted within the community, whereas SARS-CoV and MERS-CoV are primarily transmitted among hospitalised patients [2]. Previous studies have demonstrated that both anticipated annual viral respiratory infections and unfore-

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seen pandemic outbreaks result in three to five million cases of severe disease and up to half a million deaths worldwide [3, 4].

The unprecedented pace of vaccine development against COVID−19 and robust global vaccination efforts play critical roles in controlling the pandemic [5]. Few studies have investigated the effectiveness of various vaccine doses and schedules, including the use of different vaccines and complementary administration of a booster dose from another vaccine, in preventing disease severity and mortality during the COVID-19 pandemic. Numerous studies have sought to delineate the number of applications of the same vaccine deemed a full dose and the number of doses considered insufficient within this context [6, 7]. However, the production processes and availability of vaccines have varied across countries during the COVID-19 pandemic, leading to the implementation of mixed vaccination regimens involving different vaccines in many regions. A limited number of studies compared the incidence of severe infections among unvaccinated, partially vaccinated, and fully vaccinated individuals. Therefore, this study aimed to evaluate the efficacy of various vaccines and, more critically, to ascertain which specific vaccines and vaccination regimens are most effective in mitigating the progression to severe disease and reducing mortality rates.

METHODS

This single-centre hospital-based retrospective cohort study included patients with COVID-19 admitted to a tertiary-level hospital. The Clinical Research Ethics Committee approved this study (Approval date: 20.04.2022, Approval number: 2011-KAEK-25 2022/04-18). The study followed the ethical principles outlined in the Declaration of Helsinki and the guidelines for Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement. Informed written consent was not obtained because of the study's retrospective design.

The cohort was defined as "patients aged 18 years and older who were admitted with a diagnosis of COVID-19 between March 2020 and September 2022." According to the cohort definition, the inclusion criteria for the study population were (1) being 18 years or older, (2) having a microbiologically confirmed diagnosis of COVID-19, and (3) being admitted to the hospital. Patients for whom vaccination information, the primary independent variable of the study, was not accessible were excluded from the study. Patients vaccinated with any vaccine other than Sinovac or BNT162b2 were also excluded from the study. However, patients with missing data for other variables were not excluded to provide different types of analyses involving more variables.

Data, including patients' demographics (age and sex), vaccination status, blood group, COVID-19 Reporting and Data System (CO-RADS) stage, Acute Physiology and Chronic Health Evaluation Mortality Prediction Rate (APACHE II-MPR), acute phase reactants [ferritin (ng/mL), procalcitonin (ng/mL), and C-Reactive Protein (CRP) (mg/L)], D-dimer (mg/L FEU), troponin (ng/mL), white blood cell (WBC) count (x109/L), and platelet (×109/L) levels were obtained from electronic medical records.

The vaccination status of the patients was categorised as follows: (1) unvaccinated, (2) one- or two-dose vaccination with Sinovac, (3) two initial doses plus one-dose booster Sinovac, (3) two initial doses plus two- or more-dose booster Sinovac, (4) one- or two-dose BioNTech (BNT162b2), (5) two initial doses plus one-dose booster BNT162b2, (6) two initial doses plus two- or more-dose booster BNT162b2, (7) two initial doses Sinovac plus one-dose booster BNT162b2, and (8) two initial doses Sinovac plus two- or more-dose booster BNT162b2.The underlying rationale behind this categorisation is to consider those who received one or two doses of any vaccine as "inadequately vaccinated." In contrast, individuals who received two initial doses and one booster dose are regarded as "fully vaccinated."

The CO-RADS was used to include the radiological disease status of patients in the analysis [8]. The APACHE II comprises 12 physiological variables: age and previous disease status. The APACHE II score was converted into a percentage to derive the Mortality Prediction Rate (MPR) variable [9]. This approach allowed for the integration and standardised evaluation of multiple variables as a single independent variable.

There were two primary outcomes of the study. These are "in-hospital mortality" and "the need for an intensive care unit (ICU)". "Mortality" was defined as

"all-cause mortality during the stay in the hospital." "The need for ICU" was described as "a need for hospitalization in the intensive care unit for any reason during the stay in the hospital."

Statistical Analysis

No prior sample size was calculated. All eligible patients' data were included in the analysis. Statistical analyses were performed using SPSS version 23 (IBM Corp., Armonk, NY, USA). Descriptive statistics are presented as median with interquartile range (IQR) for numerical data and frequency (n) and percentage (%) for categorical data. Pearson Chi-square Test was used to analyse mortality and ICU admission rates among the study groups with different vaccination statuses. Univariable Logistic Regression Analyses with the Enter Method were employed for univariable analysis to estimate the effects of variables and potential covariates on mortality risk and the need for ICU risk. Several multivariable models were constructed with statistically significant variables from the univariable analyses while avoiding highly correlated independent variables. Odds Ratios (ORs) with a 95% confidence interval (CI) were used to evaluate the risk. Statistical significance was set at $P<0.05$.

RESULTS

The data of 2373 patients were included in the analysis based on the inclusion and exclusion criteria of the study. The number of patients included in the analysis decreased to 916 for some variables. Patients with missing data were not excluded from the analysis to present more comprehensive findings. The median age was 74 years, and 56.9% were male. The median body mass index (BMI) was 26.6 kg/m2, and 48.5% were unvaccinated. Although 5.5% of patients were classified as CO-RADS stage 1, 20.1% as stage 2, 20.2% as stage 3, 24.3% as stage 4, and 29.9% as stage 5, the median APACHE MPR score was 42.8%. Sepsis developed in 13 patients, and the median length of stay was 6.0 days. Notably, the levels of acute-phase reactants were elevated in all patients (Table 1).

Mortality was 85.0% (n=979) among unvaccinated patients, whereas it significantly decreased in all vaccinated groups ($P<0.001$ for the comparisons between the unvaccinated group and all vaccination regimens). Mortality rates were 66.9% in patients vaccinated with one or two-dose Sinovac, 55.9% with two-dose plus one-dose booster Sinovac, 26.1% with two-dose plus two or more-dose boosters of Sinovac, 27.3% with one or two-dose of BNT162b2, 3.3% with two-dose plus one-dose booster of BNT162b2, 3.6% with two-dose plus two or more-dose booster BNT162b2, 47.1% with two-dose Sinovac plus one-dose booster BNT162b2, and 21.7% two-dose Sinovac plus two or more-dose booster BNT162b2. The need for ICU admission followed a similar trend. Among unvaccinated patients, 81.3% (n=937) required ICU care, which was significantly higher compared to vaccinated groups ($P<0.001$ for the comparisons between the unvaccinated group and all vaccination regimens). The ICU admission rates 65.2% in patients vaccinated with one or two-dose Sinovac, 54.0% with two-dose plus one-dose booster Sinovac, 37.7% with two-dose plus two or more-dose boosters of Sinovac, 29.7% with one or two-dose of BNT162b2, 9.8% with two-dose plus one-dose booster of BNT162b2, 17.9% with two-dose plus two or more-dose booster BNT162b2, 49.6% with two-dose Sinovac plus one-dose booster BNT162b2, and 30.2% two-dose Sinovac plus two or more-dose booster BNT162b2. Overall mortality and ICU admission rates for the entire cohort were 64.0% (n=1519) and 63.3% (n=1502), respectively (data not shown).

Age was a statistically significant determinant of mortality and the need for ICU. Compared to unvaccinated individuals, all vaccination schedules were associated with reduced mortality risk. Moreover, as the number of booster doses increased, both the mortality and ICU admission risks decreased. When evaluating between vaccines, the regimen that most significantly reduced the mortality and ICU admission was the BNT162b2 vaccine at both the initial and booster doses, followed by the Sinovac initial regimen with BNT162b2 boosters. The slightest reduction in mortality was observed with the Sinovac regimen for both the initial and booster doses (Table 2). This trend was also the same for the need for an ICU (Table 3).

Three different models were employed to evaluate mortality risk for significant variables in the univariable analyses. The findings from the univariable analyses were preserved across all the models (Table 2). Similar results were obtained in the modelling of ICU

Table 1. Demographics, clinical features and laboratory findings of the patients

Characteristics	Data
Age (years), (n=2373)	74.0 (64.0-82.0)
Sex, n (%) (n=2373)	
Female	1022 (43.1)
Male	1351 (56.9)
BMI (kg/m^2), (n=916)	26.6 (23.4-31.1)
Blood group, n (%) (n=2146)	
0 Rh (-)	105 (4.9)
0 Rh (+)	551 (25.7)
A Rh (-)	101 (4.7)
A Rh (+)	864 (40.3)
B Rh (-)	42 (2.0)
B Rh (+)	320 (14.9)
AB Rh (-)	14 (0.7)
AB Rh (+)	149 (6.9)
Vaccine status, n (%) (n=2373)	
Unvaccinated	1152 (48.5)
One or two-dose Sinovac	408 (17.2)
Two-dose plus one-dose booster Sinovac	202 (8.5)
Two-dose plus two or more-dose booster Sinovac	69 (2.9)
One or two-dose BNT162b2	172 (7.2)
Two-dose plus one-dose booster BNT162b2	92 (3.9)
Two-dose plus two or more-dose booster BNT162b2	28 (1.2)
Two-dose plus one-dose booster mix	121 (5.1)
Two-dose plus two or more-dose booster mix	129 (5.4)
CO-RADS, n (%) (n=2108)	
1	115 (5.5)
2	423 (20.1)
3	426 (20.2)
4	513 (24.3)
5	631 (29.9)
APACHE MPR (%), (n=1557)	42.8 (26.2-70.5)
Occurrence of sepsis, n (%) (n=1427)	13 (0.9)
LOS (days), (n=2373)	6.0 (2.0-11.0)
Ferritin (ng/mL), (n=1916)	602.70 (280.62-1407.41)
Procalcitonin (ng/mL), (n=593)	0.23 (0.10-0.62)
CRP (mg/L), (n=2301)	79.20 (16.20-176.00)
D-Dimer (mg/L FEU), (n=2214)	2.08 (0.95-5.72)
Troponin (ng/mL), (n=2287)	50.90 (10.94-269.60)
WBC count (×10^9/L), (n=2361)	11.36 (7.62-17.42)
Platelet (×10^9/L), (n=1916)	199.00 (123.50-282.00)

Data are shown as median (IQR-Interquartile range) or n (%). BMI=Body mass index, CO-RADS=COVID-19 Reporting and Data System, APACHE MPR=Acute Physiology, Age, and Chronic Health Evaluation-Mortality Prediction Rate, LOS=Length of stay, CRP=C-Reactive Protein, WBC=White blood cell.

Table 2. **Univariable and multivariable analyses in estimating the mortality risk**

Variables	Univariable Analyses[1]		Multivariable Analyses[2]					
			Model 1 (n=2373)		Model 2 (n=2108)		Model 3 (n=1374)	
	OR (95% CI)	P value	aOR (95% CI)	P value	aOR (95% CI)	P value	aOR (95% CI)	P value
Age (years), (n=2373)	1.04 (1.03-1.05)	**<0.001**	1.04 (1.03-1.05)	**<0.001**	1.04 (1.03-1.05)	**<0.001**	1.03 (1.02-1.04)	**<0.001**
Male sex, (n=2373)	1.06 (0.90-1.25)	0.534						
Vaccine status, (n=2373)								
Unvaccinated	Reference		Reference		Reference		Reference	
One or two-dose Sinovac	0.36 (0.28-0.46)	**<0.001**	0.29 (0.22-0.38)	**<0.001**	0.23 (0.28-0.46)	**<0.001**	0.36 (0.21-0.60)	**<0.001**
Two-dose plus one-dose booster Sinovac	0.22 (0.16-0.31)	**<0.001**	0.17 (0.12-0.24)	**<0.001**	0.12 (0.16-0.31)	**<0.001**	0.19 (0.10-0.34)	**<0.001**
Two-dose plus two or more-dose booster Sinovac	0.06 (0.04-0.11)	**<0.001**	0.05 (0.03-0.09)	**<0.001**	0.04 (0.04-0.11)	**<0.001**	0.03 (0.01-0.07)	**<0.001**
One or two-dose BNT162b2	0.07 (0.05-0.10)	**<0.001**	0.08 (0.06-0.12)	**<0.001**	0.07 (0.05-0.10)	**<0.001**	0.15 (0.07-0.29)	**<0.001**
Two-dose plus one-dose booster BNT162b2	0.01 (0.01-0.02)	**<0.001**	0.01 (0.01-0.03)	**<0.001**	0.01 (0.01-0.02)	**<0.001**	0.01 (0.01-0.05)	**<0.001**
Two-dose plus two or more-dose booster BNT162b2	0.01 (0.01-0.05)	**<0.001**	0.01 (0.01-0.06)	**<0.001**	0.01 (0.01-0.05)	**<0.001**	0.01 (0.01-0.14)	**<0.001**
Two-dose Sinovac plus one-dose booster BNT162b2	0.16 (0.11-0.23)	**<0.001**	0.13 (0.09-0.19)	**<0.001**	0.09 (0.11-0.23)	**<0.001**	0.16 (0.07-0.33)	**<0.001**
Two-dose Sinovac plus two or more-dose booster BNT162b2	0.05 (0.03-0.08)	**<0.001**	0.04 (0.03-0.07)	**<0.001**	0.03 (0.03-0.08)	**<0.001**	0.04 (0.02-0.09)	**<0.001**
Blood group, (n=2146)								
0 Rh (-)	2.39 (0.77-7.38)	0.131						
0 Rh (+)	1.77 (0.61-5.12)	0.293						
A Rh (-)	1.97 (0.64-6.08)	0.238						
A Rh (+)	1.79 (0.76-5.14)	0.282						
B Rh (-)	1.63 (0.48-5.50)	0.435						
B Rh (+)	1.94 (0.66-5.66)	0.228						
AB Rh (-)	Reference							
AB Rh (+)	1.66 (0.55-4.98)	0.366						
CO-RADS, (n=2108)								
1					Reference		Reference	
2					1.71 (1.05-2.79)	**0.005**	1.33 (0.54-3.27)	0.542
3					2.47 (1.50-4.06)	**<0.001**	1.51 (0.61-3.76)	0.374
4					2.60 (1.59-4.23)	**<0.001**	1.57 (0.65-3.78)	0.320
5					3.40 (2.10-5.51)	**<0.001**	3.12 (1.27-7.65)	**0.013**
APACHE MPR (%), (n=1557)							1.04 (1.03-1.05)	**<0.001**

OR=Odds Ratio, aOR=Adjusted Odds Ratio, CI=Confidence interval, CO-RADS=COVID-19 Reporting and Data System, APACHE MPR=Acute Physiology and Chronic Health Evaluation Mortality Prediction Rate.

[1]Univariate Logistic Regression Model with the Enter Method was used.

[2]Multivariate Logistic Regression Models with the Enter Method were used. The variables shown in each column were included in the model.

[3]"n" in the first column shows the number of patients included in the univariable analyses.

Table 3. Univariable and multivariable analyses in estimating the need for ICU risks

Variables	Univariable Analyses[1]		Multivariable Analyses[2]											
			Model 1 (n=2373)		Model 2 (n=2146)		Model 3 (n=1896)		Model 4 (n=1314)		Model 5 (n=2108)		Model 6 (n=1374)	
	OR (95% CI)	P value	aOR (95% CI)	P value	aOR (95% CI)	P value	aOR (95% CI)	P value	aOR (95% CI)	P value	aOR (95% CI)	P value	aOR (95% CI)	P value
Age (years), (n=2373)	1.03 (1.02-1.04)	**<0.001**	1.02 (1.02-1.03)	**<0.001**	1.03 (1.02-1.04)	**<0.001**	1.03 (1.02-1.04)	**<0.001**	1.01 (0.99-1.03)	0.197	1.02 (1.02-1.03)	**<0.001**	1.01 (0.99-1.03)	0.280
Male sex, (n=2373)	1.07 (0.90-1.26)	0.445												
Vaccine status, (n=2373)														
Unvaccinated	Reference		Reference		Reference		Reference		Reference		Reference		Reference	
One or two-dose Sinovac	0.43 (0.33-0.55)	**<0.001**	0.38 (0.30-0.49)	**<0.001**	0.34 (0.26-0.45)	**<0.001**	0.37 (0.27-0.50)	**<0.001**	0.27 (0.14-0.53)	**<0.001**	0.41 (0.14-0.53)	**<0.001**	0.31 (0.17-0.56)	**<0.001**
Two-dose plus one-dose booster Sinovac	0.27 (0.20-0.37)	**<0.001**	0.23 (0.17-0.32)	**<0.001**	0.20 (0.14-0.29)	**<0.001**	0.20 (0.14-0.29)	**<0.001**	0.14 (0.07-0.31)	**<0.001**	0.22 (0.07-0.31)	**<0.001**	0.14 (0.07-0.27)	**<0.001**
Two-dose plus two or more-dose booster Sinovac	0.14 (0.08-0.23)	**<0.001**	0.13 (0.08-0.21)	**<0.001**	0.10 (0.06-0.18)	**<0.001**	0.11 (0.06-0.19)	**<0.001**	0.03 (0.01-0.10)	**<0.001**	0.14 (0.01-0.10)	**<0.001**	0.05 (0.02-0.14)	**<0.001**
One or two-dose BNT162b2	0.10 (0.07-0.14)	**<0.001**	0.12 (0.08-0.17)	**<0.001**	0.10 (0.07-0.15)	**<0.001**	0.12 (0.08-0.18)	**<0.001**	0.13 (0.07-0.30)	**<0.001**	0.14 (0.07-0.30)	**<0.001**	0.17 (0.08-0.37)	**<0.001**
Two-dose plus one-dose booster BNT162b2	0.03 (0.01-0.05)	**<0.001**	0.03 (0.02-0.07)	**<0.001**	0.02 (0.01-0.05)	**<0.001**	0.01 (0.01-0.04)	**<0.001**	0.01 (0.01-0.03)	**<0.001**	0.02 (0.01-0.03)	**<0.001**	0.01 (0.01-0.05)	**<0.001**
Two-dose plus two or more-dose booster BNT162b2	0.05 (0.02-0.13)	**<0.001**	0.06 (0.02-0.16)	**<0.001**	0.04 (0.01-0.12)	**<0.001**	0.04 (0.01-0.12)	**<0.001**	0.01 (0.01-0.05)	**<0.001**	0.05 (0.01-0.05)	**<0.001**	0.01 (0.01-0.09)	**<0.001**
Two-dose Sinovac plus one-dose booster BNT162b2	0.23 (0.15-0.33)	**<0.001**	0.20 (0.14-0.30)	**<0.001**	0.18 (0.12-0.28)	**<0.001**	0.21 (0.13-0.33)	**<0.001**	0.26 (0.09-0.74)	**0.011**	0.23 (0.09-0.74)	**<0.001**	0.29 (0.11-0.72)	**0.008**
Two-dose Sinovac plus two or more-dose booster BNT162b2	0.10 (0.07-0.15)	**<0.001**	0.09 (0.06-0.14)	**<0.001**	0.08 (0.05-0.12)	**<0.001**	0.08 (0.05-0.13)	**<0.001**	0.06 (0.03-0.14)	**<0.001**	0.10 (0.03-0.14)	**<0.001**	0.08 (0.04-0.17)	**<0.001**
Blood group, (n=2146)														
0 Rh (-)	1.74 (1.01-3.01)	**0.048**			1.78 (0.95-3.35)	0.073	2.02 (1.01-4.02)	**0.047**	3.03 (0.62-14.74)	0.171				
0 Rh (+)	1.20 (0.83-1.75)	0.339			1.19 (0.77-1.84)	0.443	1.21 (0.78-1.92)	0.430	1.48 (0.60-3.63)	0.395				
A Rh (-)	1.19 (0.70-2.02)	0.526			1.35 (0.73-2.49)	0.335	1.26 (0.67-2.39)	0.473	0.78 (0.24-2.52)	0.680				
A Rh (+)	1.10 (0.77-1.57)	0.610			1.17 (0.77-1.78)	0.468	1.17 (0.75-1.84)	0.488	1.61 (0.67-3.78)	0.274				
B Rh (-)	1.34 (0.65-2.80)	0.430			1.77 (0.71-4.40)	0.221	1.95 (0.72-5.31)	0.189	n.a.	n.a.				
B Rh (+)	1.31 (0.87-1.96)	0.199			1.35 (0.84-2.17)	0.217	1.40 (0.84-2.32)	0.194	2.15 (0.79-5.80)	0.132				
AB Rh (-)	1.08 (0.35-3.40)	0.890			1.79 (0.40-7.96)	0.447	1.71 (0.38-7.67)	0.486	n.a.	n.a.				
AB Rh (+)	Reference				Reference		Reference		Reference					
CO-RADS, (n=2108)														
1	Reference						Reference		Reference		Reference		Reference	
2	1.88 (1.25-2.83)	**0.002**					2.01 (1.21-3.34)	**0.007**	1.99 (0.68-5.81)	0.210	1.97 (1.24-3.14)	**0.004**	2.45 (0.94-6.38)	0.067
3	2.03 (1.34-3.08)	**0.001**					2.25 (1.37-3.72)	**0.001**	1.53 (0.55-4.27)	0.418	1.98 (1.26-3.13)	**0.003**	1.72 (0.70-4.26)	0.239
4	2.32 (1.53-3.53)	**<0.001**					2.46 (1.47-4.10)	**0.001**	2.29 (0.77-6.79)	0.135	2.35 (1.48-3.75)	**<0.001**	2.69 (1.02-7.07)	**0.045**
5	2.31 (1.55-3.46)	**<0.001**					3.07 (1.87-5.03)	**<0.001**	3.50 (1.22-10.04)	**0.020**	2.62 (1.67-4.12)	**<0.001**	3.48 (1.38-8.78)	**0.008**
APACHE MPR (%), (n=1557)	1.07 (1.06-1.09)	**<0.001**							1.08 (1.06-1.10)	**<0.001**			1.07 (1.05-1.09)	**<0.001**

OR=Odds Ratio, aOR=adjusted odds ratio, CI=confidence interval, CO-RADS=COVID-19 Reporting and Data System, APACHE MPR=Acute Physiology and Chronic Health Evaluation Mortality Prediction Rate.

[1]Univariable Logistic Regression Model with the Enter Method was used.

[2]Multivariable Logistic Regression Models with the Enter Method were used. The variables shown in each column were included in the model.

[3]"n" in the first column shows the number of patients included in the univariable analyses.

admission needs. While effect modifications were observed for other variables across the six different models, the trends in the findings related to vaccination regimens remained consistent (Table 3).

DISCUSSION

Our study revealed that all vaccinated groups, including those receiving only one dose of the Sinovac or BNT162b2 regimen, had lower rates of ICU admission during hospitalisation and lower mortality rates than unvaccinated patients. Specifically, ICU admissions and mortality rates were lower in the BNT162b2 vaccinated group compared to the Sinovac-vaccinated group. Moreover, individuals who received a two-dose regimen of BNT162b2 followed by a booster dose (BNT162b2d), or two doses of BNT162b2 with two or more booster doses exhibited the lowest ICU admission rates (9.8% and 17.9%) and mortality rates (3.3% and 3.6%) compared to those who received two doses of Sinovac with one or more booster doses or two doses of Sinovac followed by one BNT162b2 booster dose. Conversely, the most significant reductions in mortality risk and ICU admission were observed in individuals who received BNT162b2 at both the initial and booster doses. Our study also identified age, CO-RADS stage, and APACHE MPR score as statistically significant determinants of mortality and ICU admission.

Individuals of different age groups can be affected by this highly transmissible disease. However, people aged ≥60 years and those with comorbidities such as diabetes, cardiovascular disease, obesity, and chronic lung disease are particularly vulnerable to severe clinical illness and mortality [10]. Additionally, numerous studies indicate that this disease tends to be more severe in men and is associated with higher mortality rates [11, 12]. Our study cohort had a higher median age, and 56.9% were male and considered at high risk for severe infection [7].

The virulence of the virus and the host immune response determine the severity of SARS-CoV-2-induced illness. At the same time, a controlled immune response in mild infections leads to viral clearance, an excessive and uncontrolled immune response, characterised by aberrant cytokine and chemokine activity, results in the infiltration of inflammatory cells, destruction of the respiratory epithelial layer, and consequently respiratory failure in severe cases [13, 14]. Elevated levels of CRP, ferritin, D-dimer, and troponin have been identified as risk factors associated with the severity of the clinical course in patients with COVID-19 [7, 15].

Like other respiratory RNA viruses, SARS-CoV-2 undergoes various mutations as it adapts to its new host, leading to differences from the original strain [5]. Many studies have demonstrated that mRNA and inactivated vaccines are effective against several variants, including Alpha, Beta, Gamma, and Delta, albeit in varying degrees [16, 17]. A population-based study encompassing over seven thousand COVID-19-associated hospitalisations of adults 65 years and older showed that 75% of the cases were unvaccinated, 12% were partially vaccinated, and only 5% were fully vaccinated [18]. In the present study, 50% of the patients were unvaccinated, 40% were partially vaccinated, and 10% were fully vaccinated. A vaccine schedule consisting of two doses plus one or two booster doses was considered fully vaccinated in patients with advanced age and additional comorbidities [7, 19].
A multicentre historical control study investigating the severity and outcomes of COVID-19 among vaccinated compared to unvaccinated patients found that unvaccinated or partially vaccinated individuals experienced more in-hospital complications, severe disease, and death than fully vaccinated individuals [7]. Unvaccinated individuals more frequently show abnormal findings on chest imaging, with more widespread involvement observed at the onset of COVID-19 infection [7, 20]. In addition, these patients were more likely to require ICU admission and experienced a higher death rate than vaccinated individuals. Our experience with the current pandemic indicates that advanced age is a significant risk factor for severe clinical course and disease-related mortality [21, 22].

The severity of the current pandemic was lowest in the fully vaccinated group and highest in the unvaccinated group, and it was between these two groups in partially unvaccinated people, remarking the protective role of mRNA vaccines against severe COVID-19 disease [7]. Heterologous prime-booster and a third dose vaccination induced a robust humoral response in all adult age groups [16, 23]. Our study underscores the importance of delineating effective vaccines and

optimal vaccination schedules, particularly in elderly cohorts. Our findings highlight the potential need for tailored full-dose vaccination protocols based on the specific vaccine in specific patient groups.

Limitations

Since our study was a single-centre hospital-based retrospective analysis, the generalisability of the study is limited. Another potential limitation of the study is the possibility of data source errors, as the study data were obtained from electronic medical records. Some patient characteristics, such as comorbidities, and their potential impact on the outcomes were not assessed. Additionally, the treatment modalities administered before admission and during hospitalisation with discussions on their accessibility and efficacy were not detailed. Readers should keep these limitations in mind when interpreting the results.

CONCLUSION

As a result, a two-dose initial plus one or more-dose booster BNT162b2 regimen showed the highest effectiveness in reducing the risks of mortality and ICU admission compared to partially vaccinated regimens and the unvaccinated group. Our study group consisted of very elderly patients who presented with a severe clinical course, which may explain the high mortality rates.

Ethical Statement

This study was approved by the University of Health Sciences, Bursa Yüksek Ihtisas Training and Research Hospital, Clinical Research Ethics Committee (Decision no. 2011-KAEK-25 2022/04-18, date: 20.04.2022).

Authors' Contribution

Study Conception: AT, HÖ, AAV; Study Design: AT, HÖ, HB; Supervision: AT, HÖ, NK; Funding: AT, AAV, NK; Materials: AT, AAV, HB; Data Collection and/or Processing: AT, AAV, NK; Statistical Analysis and/or Data Interpretation: AT, HÖ; Literature Review: AT, AAV, HB; Manuscript Preparation: AT, HÖ, AAV, NK, HB and Critical Review: AT, HÖ, AAV, NK, HB.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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Generative Artificial Intelligence Statement

The author(s) declare that no artificial intelligence-based tools or applications were used during the preparation process of this manuscript. The all content of the study was produced by the author(s) in accordance with scientific research methods and academic ethical principles.

Editor's note

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