Impact of COVID-19 vaccination drive against COVID-19 illness and deaths in a tertiary care centre

Arpit Chelabhai Prajapati[1,*], Mansi Maulik Patel[2], Rujul P Shukla[2], Viral R Dave[1], Heena Chhanwal[3], Ankita Patel[3] and Parita Gandhi[3]

[1]Department of Community Medicine, GCS Medical College, Ahmedabad, Gujarat 380025, India
[2]Department of Community Medicine, Ananya College of Medicine & Research, Ahmedabad, Gujarat 382721, India
[3]Department of Anaesthesia, GCS Medical College, Ahmedabad, Gujarat 380025, India

Abstract

Introduction: In response to the COVID-19 pandemic, worldwide efforts to develop vaccines to give protection against COVID-19. Despite the record speed at which have been developed, COVID-19 vaccines have still been subject to the same checks, balances, and scientific and regulatory rigour as any other vaccine, and shown to be safe. The study aimed to establish the relationship of vaccination on length of stay.

Materials and methods: A retrospective cohort study was carried out among all 1123 COVID-19 patients admitted or discharged during March 2021 to June 2021 at tertiary care centre. Hospital records of all COVID-19 patients admitted during study duration were assessed for the required information and also telephonic interview taken if needed. Descriptive statistics were used to assess the distribution of factors among the patients.

Results: Of total 1123 inpatients, 21.7% had received a single dose of COVID-19 vaccine while 74.9% had not received any form of COVID-19 vaccination. Mean length of stay in hospital was similar (7.6 days). Among all, 81.3% were nonvaccinated. The mean length of stay in ICU for the two doses received vaccinated was 4.2 ± 3.0 days while unvaccinated patients was 5.1 ± 2.6 days. Mortality rate was 3.6% patients in the two doses vaccinated group and 74.4% in the non-vaccinated group found.

Conclusion: Among vaccinated patients there was a 75% relative risk reduction in ICU admission. There was no difference observed in duration of stay among vaccinated or unvaccinated patients, deaths among comorbid patients.

Keywords: COVID-19; vaccine; death; length of stay

Introduction

As most studies suggested COVID-19 vaccination was effective for prevention of COVID-19 illness, there was less information available on impact of COVID-19 vaccination for on need for hospitalization in intensive care unit (ICU) in breakthrough infections. Since from December 2019, Corona virus causative agent for COVID-19, increased worldwide; as of December 13, 2021, there have been billions positive cases of corona, including billions of deaths, reported to World Health Organization (WHO). As of 29 June 2023, numerous COVID-19 vaccine doses have been administered [1].

There are numerous COVID-19 vaccines validated for emergency use by WHO. Of the whole world's first large scale COVID-19 vaccination campaign was started for the humankind in the beginning of the month December

2020 and the figure of doses of COVID-19 vaccination administered worldwide is notified on day to day basis on the WHO COVID-19 dashboard. Many COVID-19 vaccines against the illness have received approval

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for emergency use of the vaccination in COVID-19 pandemic based on achieved defined criteria for safety during pandemic. WHO is determined to maintain the momentum for increasing access to COVID-19 vaccines and will continue to support countries in accelerating vaccine delivery, to save lives and prevent people from becoming seriously ill. Countries should continue to work towards vaccinating at least 70% of their populations, prioritizing the vaccination of 100% of health workers and 100% of the most vulnerable groups, including people who are over 60 years of age and those who are immunocompromised or have underlying health conditions [2].

Deaths due to COVID-19 have occurred in people of all age but most deaths occur among older people and people having chronic diseases like diabetes, hypertension, respiratory disease. In this global pandemic, world is facing worldwide illness and caused so much morbidity and mortality globally. In response to the COVID-19 pandemic, in the history of community health, worldwide efforts to develop numerous vaccines to provide protection against this highly infectious illness - COVID-19 have been greatest [3].

People may be infected with COVID-19 just before or after vaccination and still get sick with COVID-19. Because it can take several weeks to develop immunity after vaccination, it is possible to become infected in this period immediately following vaccination. Vaccines can effectivily prevent infection, progression to severe disease, and death due to COVID-19. Majority of the people who contract the disease are unvaccinated. As there is no any vaccine 100% effective at preventing illness, people who have taken vaccine may still get COVID-19. "Vaccine breakthrough infection" is known as an infection that develops in a fully vaccinated person [4]. Person who had not taken any dose of COVID-19 vaccine are at greater chances of getting corona virus infection. Few person including lower age group having the disease may be suffering from severe illness, and they need to be admitted in intensive care unit, and those who got infection may be having ongoing health issues several months or even more after becoming ill [5].

Fully vaccinated individuals who have low immunity due to medicine which was taken for their illness may not be protected fully. These people should follow all the necessary precautions advised for susceptible individual, including wearing a face mask, until advised otherwise by their healthcare provider [5]. The direct association between death due to COVID-19 and immunization coverage among elderly people was not examined many research studies, analyses could be conducted with more detailed data and more availability of information on vaccination status for reported deaths [6]. COVID-19 vaccines is key to control the disease to tackle pandemics along with other recommended precautions. Promotion of well-being of all citizens of countries is the main objective of COVID-19 vaccines and significant contribution in public health.

The study was carried out with the objective to establish the relationship of vaccination and non-vaccination on mean length of stay, ICU requirement among hospitalized COVID-19 patients and to study the association between outcome of COVID-19 infection and vaccination.

Materials and methods

A retrospective cohort study (case record and interview-based study) was carried out among all COVID-19 inpatients admitted during March 2021 to June 2021 at GCS Medical College, Hospital and Research Centre, one of the tertiary care center of Ahmedabad city. In second phase of COVID-19 pandemic, this tertiary care hospital was COVID-19 designated hospital and the COVID-19 patients were admitted at this hospital. From the total admitted during second phase of COVID-19, this hospital was designated COVID-19 and all COVID-19 positive patients other than non COVID-19 pateints admitted during this period were included in the study. Inclusion criteria for the study participants were positive COVID-19 cases (COVID-19 PCR test/ rapid antigen detection kit test/ radiologically suggestive of COVID-19 by HRCT) admitted at tertiary care hospital and patients aged more than 18 years and above. To achieve the objective of the study, all COVID-19 patients hospitalized or discharged during March 2021 to June 2021 were taken as study subjects and their hospital records were assessed for the required information and also telephonic interview taken by author for other information which was not mentioned in case paper during the month of September and October 2021 retrospectively.

In this study, data was collected from all 1123 COVID-19 patient's case records and required missing information through telephonic interview using pre tested & predesigned questionnaires by authors themselves. COVID-19 patients whose details were not found in case records were interviewed telephonically by author for the missing information of study proforma. Those patients who died before discharge, their first degree relative who had all information were interviewed for the information by the authors. Proforma was developed by authors through extensive literature search and from other similar research studies. Pilot study was done before the start of the study on the admitted COVID-19 patients at the isolation ward during January 2021. The

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respondents were not included in the current study as they were taken to improve the proforma of the study.

After obtaining informed consent, the telephonic interview was taken of study participants and data was collected and entered in MS Office 2010 and analyzed through Epi Info™ Version 7.2. Data regarding sociodemographic information, comorbidity, death, length of hospital stay, ICU admission required and COVID-19 vaccination status (1st and 2nd dose) was taken by authors. The analysis of the data was done by MS Excel 2010 and Epi InfoTM Version 7.2. The frequency, percentage and test of association (Chi Square test) were used for the analysis in this research study. This research study was approved by Institutional Ethics Committee. Trial was registered at the Clinical Trials Registry- India (ICMR CTRI/2021/12/039015).

Results

There were total 682 (60.7%) males and 441 (39.3%) female among total COVID-19 inpatients. Mean age of admitted COVID-19 patient was 55.7 ± 14.8 years. Of the 1123 patients who were admitted at COVID-19 designated tertiary care centre and participants of the current research study, 244 (21.7%) participants had taken one dose of COVID-19 vaccine, 38 (3.4%) participants had received two doses of COVID-19 vaccine while 841 (74.9%) participants had not taken any dose of COVID-19 vaccine. Among total COVID-19 patients admitted in ICU, 81.3% were nonvaccinated, 15.6% had taken one dose of COVID-19 vaccine (partially immunized) while 3.1% had taken two doses of vaccine (Fully immunized) (Table 1 & Table 2).

Table 1: Baseline characteristics of patients with COVID-19 illness and vaccination status.

Characteristic	Vaccination status (n=1123)			p value*
	Unvaccinated (%) (n=841)	Partially vaccinated (Single dose) (n=244) (%)	COVID-19 Vaccinated (Both doses) (n=38) (%)	
Total numbers of COVID-19 patients (N=1123)	841 (74.9%)	244 (21.7%)	38 (3.4%)	---
Sex				
Male (n=682)	503 (73.6%)	153 (22.5%)	26 (3.9%)	0.44
Female (n=441)	338 (76.6%)	91 (20.7%)	12 (2.7%)	
Age group (in years old)				
18 to 25	21 (95.5%)	01 (4.5%)	0 (0.0%)	
25 to 35	101 (91.0%)	07 (6.3%)	3 (2.7%)	
35 to 45	136 (95.1%)	06 (4.2%)	1 (0.7%)	
45 to 55	179 (76.5%)	51 (21.8%)	04 (1.7%)	<0.0001
55 to 65	219 (69.3%)	83 (26.3%)	14 (4.4%)	
65 to 75	127 (61.4%)	70 (33.8%)	10 (4.8%)	
>75	58 (64.4%)	26 (28.9%)	06 (6.7%)	
Bed category of hospitalization				
Admitted to intensive care unit (n=160)	130 (81.3%)	25 (15.6%)	05 (3.1%)	
Required mechanical ventilation (n=135)	110 (81.5%)	21 (15.5%)	04 (3.0%)	---
Admitted in high dependency unit bed (n=557)	407 (73.1%)	127 (22.8%)	23 (4.1%)	
Admitted in isolation bed (n=406)	304 (74.9%)	92 (22.7%)	10 (2.5%)	

*Chi-square test.

Total 246 deaths (21.9%) occurred amongst 1123 COVID-19 patients. Mortality rate was 3.6% in the two doses vaccinated group, 22% in single dose vaccinated group and 74.4% in the non-vaccinated group found. The deaths among elderly cases due to the more transmissible variant and also other risk factors like relatively low immunity following vaccination, or

waning vaccine immunity and or loosening COVID-19 mitigation measures.

Among the unvaccinated patients 130/841 (15.5%), single dose vaccinated 25/244 (10.3%) and 5/38 (13.2%) the two doses vaccinated required ICU admission. Among those patients who had taken one or

Table 2: Age wise distribution of COVID-19 deaths according to the COVID-19 vaccine status.

| Age groups (In years) | COVID-19 deaths (n=246) | | | p value* |
	Unvaccinated (n=841) (%)	Partially vaccinated (Single dose) (n=244) (%)	COVID-19 Vaccinated (Both doses) (n=38) (%)	
18 to 45	29 (100%)	00 (0.0%)	00 (0.0%)	
45 to 55	32 (82.1%)	05 (12.8%)	02 (5.1%)	
55 to 65	61 (72.6%)	20 (23.8%)	03 (3.6%)	0.010
> 65	61 (62.1%)	29 (34.5%)	04 (3.4%)	
Total	183 (74.4%)	54 (22.0%)	9 (3.6%)	
Severity of illness (n= 1123)				
ICU admission	130 (15.5%)	25 (10.3%)	05 (13.2%)	
Non ICU admission	711 (84.5%)	219 (89.7%)	33 (86.8%)	0.11
Total	841 (74.9)	244 (21.7)	38 (3.4)	

*Chi-square test

two doses of vaccination against COVID-19, there was a 75% relative risk reduction in ICU admission.

The mean number of days of hospital stay in tertiary care center was comparably same (7.6 days) for these three groups (unvaccinated, single dose vaccinated & two dose vaccinated); There was no statistical difference observed in mean duration of stay at hospital for COVID-19 patients among vaccinated or unvaccinated patients (Table 3). The average hospital stay in ICU was 4.2 ± 3.0 days for patients two had taken two doses of COVID-19 requiring intensive care, those who had taken single dose of COVID-19 vaccine was 6.3 ± 2.6 days while of patients who had not taken vaccine was 5.1 ± 2.6 days. There was no significant difference found in deaths among comorbid patients according to their vaccination status (p value >0.05) (Table 4).

Table 3: length of stay of COVID-19 admitted patients.

Vaccination status	Mean duration of hospital stay (in days)
Unvaccinated (n=841)	7.6 ± 5.5 days
Partially vaccinated (single dose)(n=244)	7.6 ± 5.4 days
COVID-19 Vaccinated (Both doses) (n=38)	7.5 ± 5.2 days

In the current study, out of total 1123 COVID-19 patients, 682 (60.7%) males and 441 (39.3%) female. Mean age of admitted COVID-19 patient was 55.7 ± 14.8 years. In the current study, among the unvaccinated patients (15.5%), single dose vaccinated (10.3%) and the two dose vaccinated (13.2%) were required admission in ICU. Among those who received COVID-19 vaccine (one or two doses), there was a 75% relative risk reduction

in ICU admission while COVID-19 vaccination was associated with 69.3% relative risk reduction (RRR) in death rate. In this study, we observed no statistical difference in mean duration of stay at hospital for COVID-19 patients among vaccinated or unvaccinated patients, deaths among comorbid patients according to their vaccination status.

Table 4: Mortality among comorbid and unvaccinated patients.

| Comorbidity | Deaths (n=246) | | p value* |
	Unvaccinated	Vaccinated	
Present	77	30	
Absent	106	33	0.4
Total	183	63	

*Chi-square test

Discussions

Critical steps to COVID-19 infection are recognition of the ACE2 receptor by virus called SARS-CoV-2 and the subsequent conformational changes in the structure of S protein. This protein's significance, its structure and interactions with host receptors represent a widespread niche to study for development of new drugs and a vaccine to prevent it [7]. WHO and its various research partners are dedicated to accelerating the developing COVID-19 vaccines with highest standards on safety. Newer vaccine will go through different phases of development and testing and ultimately the last phase of assessment of the ability of the product to protect against particular disease. More number of vaccines in development, there are higher chances of getting success. Any longer-term safety assessment of vaccine

always conducted through continued follow up of the participating population and also through specific studies and general pharmacovigilance of those being vaccinated in the roll out [8].

At the time of 2nd wave of COVID-19 pandemic in India (March 2021 to June 2021) according to the guideline, patients who have mild disease upper respiratory tract symptoms and or fever without shortness of breath or hypoxia were given home isolation and care. So in the current study, these outdoor patients (OPD) were not included. Those patients having moderate to severe COVID-19 disease who were admitted in COVID-19 isolation wards, High Dependency Unit (HDU) and ICU during the time of pandemic were taken into the study [9]. Improve coverage of COVID-19 vaccine doses can prevent severity of disease and lead to early recovery of patients not requiring hospitalization [10]. This may be the reason for higher number of nonvaccinated patients hospitalized in the current study.

Total 1123 COVID-19 patients admitted, 682 (60.7%) males and 441 (39.3%) female. Mean age of admitted COVID-19 patient was 55.7 ± 14.8 years. Total 244 (21.7%) participants had taken one dose of COVID-19 vaccine, 38 (3.4%) participants had received two doses of COVID-19 vaccine while 841 (74.9%) participants had not taken any dose of COVID-19 vaccine.

In other study, it was observed that Inpatients aged ≥70 years had experienced a relatively high mortality during research study. In-hospital mortality was similar between both the groups (p = 0.81). Authors of the study observed more deaths among elderly patients and this increase was in spite of their COVID-19 vaccination status [11].

In a similar study conducted in tertiary care centre, it was found 61% men and 39% women, with an average age of 55.6 ± 15.8 years. There was statistical significance difference was observed between mean age of patients who have taken vaccine (61.7 ± 15.7 years) and mean age of patients who had not taken vaccine (53.6 ± 12.1 years) [12].

The criteria for COVID-19 vaccination are determined by the risk of severe illness and death, ethical principles of justice and equity, and considerations related to reviving crippled economies. Observational studies of vaccine effectiveness after COVID-19 vaccines are introduced are the only way to answer key questions about COVID-19 vaccines and will still be essential post-introduction. Outcomes that are of interest for post COVID-19 vaccination like severe disease, death, symptomatic or asymptomatic infection, transmission.

Among the unvaccinated patients 130/841 (15.5%), single dose vaccinated 25/244 (10.3%) and 5/38 (13.2%) the two doses vaccinated required ICU admission. Among those patients who had taken one or two doses of vaccination against COVID-19, there was a 75% relative risk reduction in ICU admission.

In this study, among those who received COVID-19 vaccine (one or two doses), there was a 75% relative risk reduction in ICU admission while COVID-19 vaccination was associated with 69.3% relative risk reduction (RRR) in death rate. Among those patients who had taken COVDI-19 vaccine, their average length of stay in hospital was less [13].

In this study, we observed no statistical difference in mean duration of stay at hospital for COVID-19 patients among vaccinated or unvaccinated patients, deaths among comorbid patients according to their vaccination status while in other study it was found that those patients who have taken two doses of COVID-19 vaccine also had lower likelihood of admission to intensive care units. There was no statistical difference in the average length of stay in hospital for patients who were not admitted to intensive care, nor was there a difference in the chances of mortality in hospital between vaccinated and unvaccinated patients [14]. Among other study, the association of COVID-19 vaccination with outcomes of disease, those who received two or more vaccine doses had significantly lower risk of health outcomes as compared to those who did not receive the vaccine, no significant difference was found between patients who received one dose of vaccine and unvaccinated COVID-19 patients [10].

COVID-19 presents at different degree of severity of illness. Care during hospital stay also can vary from isolation care as per guideline to high dependency units (HDUs) with oxygen support to intensive care where patients may require intubation for artificial ventilation. The Length of hospital stay is more likely to depend on the level of hospital care required individually as well as the demographic & geographic setting due to various COVID-19 guidelines. As the knowledge of effective treatments protocol changes, the pathways, staff, beds and equipment & oxygen required were also likely to affect the duration and level of hospital care needed. Apart from COVID-19 vaccination status, other patient characteristics like age and comorbidities were also likely to impact disease severity and are likely to effect Length of stay [15].

In other similar study, among the patients hospitalised because of COVID illness, full vaccination was associated with less severe forms of disease, with an earlier

discharge date. severe COVID-19 was more frequent among the not vaccinated patients (50.4%) than among vaccinated (37.3%); OR, 1.70; 95% CI (1.02–2.82); p = 0.001 [11].

Other study results suggested that after COVID-19 vaccination, COVID-19 illness was mostly mild if infected than in patients who had not taken vaccine, death rate was higher side in inpatients: data from the ISARIC Consortium (International Severe Acute Respiratory and Emerging Infection) have showed in patients hospitalised with COVID-19 in the United Kingdom who had taken vaccine 21 days before, 27.0% deaths observed, it was nearly the same death rates observed during first wave of COVID-19 pandemic [16-18]. Vaccination drive at Israel (Data from surveillance system of Nation) also found two doses of BNT162b2 reduced COVID-19-related admission in hospital, severe disease, and mortality among them [19].

The average hospitalization days of stays for single dose vaccinated patients were 9 days while 12 days for unvaccinated patients; (p value < 0.05) and the observed more serious disease among vaccinated (30.3%) as compared to partially vaccinated - single dose (51.3%) and unvaccinated (54.1%) (p value < 0.05) were significantly low among patients who had taken vaccine as compared to patients who had not [20]. Among those patients who had taken two doses of vaccine, 3.2% patients were hospitalized, 0.5% admitted to an ICU and 0.2% required ventilator while among patients who had taken one dose vaccine (6.2%, 1.0%, and 0.3%, respectively) and among unvaccinated patients (7.6%, 1.5%, and 0.5%, respectively) (p<0.001). The median age of hospitalized patients and patients admitted in an ICU was same as of 64 years among vaccinated patients, the median age of partially vaccinated persons was 59 and 65 years respectively while the median age of unvaccinated persons was 49 and 56 respectively (p<0.001) [21].

The aOR of confirmed COVID-19 (RT-PCR) were high among those who have not taken vaccine and past illness due to corona than among patients who were taken two doses of vaccine without any evidence of COVID-19 illness in the analysis of the hospitalized data of COVID-19 like disease (previously infected or vaccination history of 3 months to 6 months earlier) having more than 18 years of age during the period of January to September 2021. Past illness with Corona virus that is responsible for COVID-19 illness or immunity developed following COVID-19 vaccine and give protection from subsequent disease manifestation [22]. In other study conducted at many places of USA, among total COVID-19 inpatients who had not taken

vaccine were likely require invasive ventilatory support by day 28 and death may occur. (12.0% vs 24.7%; aOR, 0.33; 95% CI, 0.19-0.58) [23].

This study was conducted in hospital settings so more numbers of unvaccinated patients were found. This was the limitation of our study. If it can be repeated in larger scale with large sample size involving other teartiary care hospital of the Ahmedabad city, it would give the more genralized results. Biases may cause change in either direction making this vaccine more or less protective than it is, and the extent of particular biases may change during the course of a study.

Conclusions

Among vaccinated patients (received one or two doses of COVID-19 vaccine), there was a 75% relative risk reduction in ICU admission. There is no statistical difference observed in mean duration of stay at hospital for COVID-19 patients among vaccinated or unvaccinated patients, deaths among comorbid patients according to their vaccination status. Hospital admissions due to illness are still required in both the groups (not vaccinated and in the vaccinated older group of patient). Because patients with the similar age, similar status of vaccination have a different progression and outcome (not hospitalised, hospitalised, and deaths), this can not be explained yet and reasons are still not known.

Acknowledgements

Conflicts of interest

Author declares no conflicts of interest.

References

[1] World Health Organization. WHO Coronavirus (COVID-19) Dashboard with Vaccination Data 2023. Accessed on 7 Jul 2023 from: https://covid19.who.int

[2] World Health Organization. COVID-19 vaccines 2023. Accessed on 7 Jul 2023 from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/covid-19-vaccines

[3] World Health Organization. Draft landscape and tracker of COVID-19 candidate vaccines 2023. Accessed on 7 Jul 2023 from: https://www.who.int/publications/m/item/draft-landscape-of-covid-19-candidate-vaccines

[4] National Center for Immunization and Respiratory Diseases (NCIRD) D of VD. Vaccine Breakthrough Infections: The possibility of getting COVID-19 after getting vaccinated 2023. Accessed on 7 Jul 2023 from: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/effectiveness/why-measure-effectiveness/breakthrough-cases.html

[5] Centers for disease control and prevention. Benefits of Getting a COVID-19 Vaccine | CDC 2023. Accessed on 7 Jul 2023 from: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/vaccine-benefits.html

[6] Wong MK, Brooks DJ, Ikejezie J, Gacic-Dobo M, Dumolard L, et al. COVID-19 mortality and progress toward vaccinating older adults — World Health Organization, Worldwide, 2020–2022. MMWR Morb Mortal Wkly Rep 2023; 72:113–118. Available from: https://www.cdc.gov/mmwr/volumes/72/wr/mm7205a1.htm

Prajapati AC et al. J Med Sci Res. 2024; 12(1):38-44

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[7] Mittal A, Manjunath K, Ranjan RK, Kaushik S, Kumar S, Verma V. COVID-19 pandemic: Insights into structure, function, and hACE2 receptor recognition by SARS-CoV-2. PLoS Pathog. 2020; 16:e1008762.

[8] World Health Organization. Coronavirus disease (COVID-19): Vaccine research and development 2021. Accessed on 4 Aug 2023 from: Available from: https://www.who.int/news-room/questions-and-answers/item/coronavirus-disease-(covid-19)-vaccine-research-and-development

[9] Ministry of Health and Family Welfare G. MoHFW 2021. Accessed on 8 Jul 2023 from: https://www.mohfw.gov.in

[10] Tomioka K, Uno K, Yamada M. Association between vaccination status and COVID-19-related health outcomes among community-dwelling COVID-19 patients in Nara, Japan. Environ Health Prev Med. 2023; 28:7.

[11] Ruiz-Giardin JM, Rivilla M, Mesa N, Morales A, Rivas L, et al. comparative study of vaccinated and unvaccinated hospitalised patients: a retrospective population study of 500 hospitalised patients with SARS-CoV-2 infection in a spanish population of 220,000 inhabitants. Viruses. 2022; 14:2284.

[12] Desai A, Desai P, Mehta J, Sachora W, Bharti N, et al. Measuring the impact of a single dose of ChAdOx1 nCoV-19 (recombinant) coronavirus vaccine on hospital stay, ICU requirement, and mortality outcome in a tertiary care centre. Int J Infect Dis. 2021; 113:282–287.

[13] Baltas I, Boshier FAT, Williams CA, Bayzid N, Cotic M, et al. Post-vaccination COVID-19: A case-control study and genomic analysis of 119 breakthrough infections in partially vaccinated individuals. Clin Infect Dis. 2022; 75:305–313.

[14] Whittaker R, Kristofferson AB, Salamanca BV, Seppälä E, Golestani K, et al. Length of hospital stay and risk of intensive care admission and in-hospital death among COVID-19 patients in Norway: a register-based cohort study comparing patients fully vaccinated with an mRNA vaccine to unvaccinated patients. Clin Microbiol Infect. 2022; 28:871–878.

[15] Rees EM, Nightingale ES, Jafari Y, Waterlow NR, Clifford S, et al. COVID-19 length of hospital stay: A systematic review and data synthesis. BMC Med. 2020; 18:270.

[16] Institute R, Girvan M, Harrison JB, de Angelis D, Kirwan PD, et al. Changes in in-hospital mortality in the first wave of COVID-19: a multicentre prospective observational cohort study using the WHO Clinical Characterisation Protocol UK. Lancet Respir Med. 2021; 9:773–785.

[17] Egan C, Knight S, Baillie K, Harrison E, Docherty A, et al. Hospitalised vaccinated patients during the second wave, update April '21. 2021. Available from: https://assets.publishing.service.gov.uk/media/608ab0d3e90e076ab573a192/S1208_CO-CIN_report_on_impact_of_vaccination_Apr_21.pdf

[18] Antonelli M, Penfold RS, Merino J, Sudre CH, Molteni E, et al. Risk factors and disease profile of post-vaccination SARS-CoV-2 infection in UK users of the COVID Symptom Study app: a prospective, community-based, nested, case-control study. Lancet Infect Dis. 2022; 22:43–55.

[19] Haas EJ, Angulo FJ, McLaughlin JM, Anis E, Singer SR, et al. Impact and effectiveness of mRNA BNT162b2 vaccine against SARS-CoV-2 infections and COVID-19 cases, hospitalisations, and deaths following a nationwide vaccination campaign in Israel: an observational study using national surveillance data. The Lancet. 2021; 397:1819–1829.

[20] Singh C, Naik BN, Pandey S, Biswas B, Pati BK, et al. Effectiveness of COVID-19 vaccine in preventing infection and disease severity: a case-control study from an Eastern State of India. Epidemiol Infect. 2021; 149:e224.

[21] Griffin JB, Haddix M, Danza P, Fisher R, Koo TH, et al. SARS-CoV-2 Infections and Hospitalizations Among Persons Aged ≥16 Years, by Vaccination Status — Los Angeles County, California, May 1–July 25, 2021. MMWR Morb Mortal Wkly Rep. 2021; 70:1170–1176.

[22] Bozio CH, Grannis SJ, Naleway AL, Ong TC, Butterfield KA, et al. Laboratory-confirmed COVID-19 among adults hospitalized with COVID-19–like illness with infection-induced or mRNA vaccine-induced SARS-CoV-2 immunity — nine states, January–September 2021. MMWR Morb Mortal Wkly Rep. 2021; 70:1539–1544.

[23] Tenforde MW, Self WH, Adams K, Gaglani M, Ginde AA, et al. Association between mRNA vaccination and COVID-19 hospitalization and disease severity. JAMA. 2021; 326:2043–2054.