medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

Title: Patient trajectories among hospitalised COVID-19 patients vaccinated with an mRNA vaccine in Norway: a register-based cohort study

Robert Whittaker (MSc)[a*], Anja Bråthen Kristofferson (PhD)[b], Beatriz Valcarcel Salamanca (PhD)[b], Elina Seppälä (MD)[a], Karan Golestani (MD)[c], Reidar Kvåle (PhD)[d, e], Sara Viksmoen Watle (MD)[a], Eirik Alnes Buanes (PhD)[d, f]

Family names are underlined.

a) Department of Infection Control and Vaccines, Norwegian Institute of Public Health, Oslo, Norway.
b) Department of Method Development and Analytics, Norwegian Institute of Public Health, Oslo, Norway.
c) Department of Infection Control and Preparedness, Norwegian Institute of Public Health, Oslo, Norway.
d) Department of Anaesthesia and Intensive Care, Haukeland University Hospital, Bergen, Norway.
e) Department of Clinical Medicine, University of Bergen, Bergen, Norway.
f) Norwegian Intensive Care and Pandemic Registry, Haukeland University Hospital, Bergen, Norway.

* Corresponding author: Robert Whittaker, Norwegian Institute of Public Health, Lovisenberggata 8, 0456, Oslo, Norway; Phone: +47 21 07 63 93; Email: Robert.Whittaker@fhi.no

NOTE: This preprint reports new research that has not been certified by peer review and should not be used to guide clinical practice.

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

Abstract

Objectives

With most of the Norwegian population vaccinated against COVID-19, an increasing number and proportion of COVID-19 related hospitalisations are occurring among vaccinated patients. To support patient management and capacity planning in hospitals, we estimated the length of stay (LoS) in hospital and odds of intensive care (ICU) admission and in-hospital mortality among COVID-19 patients ≥18 years who had been vaccinated with an mRNA vaccine, compared to unvaccinated patients.

Methods

Using national registry data, we conducted a cohort study on SARS-CoV-2 positive patients hospitalised in Norway between 1 February and 30 September 2021, with COVID-19 as the main cause of hospitalisation. We used a Cox proportional hazards model to examine the association between vaccination status and LoS. We used logistic regression to examine the association between vaccination status and ICU admission and in-hospital mortality.

Results

We included 2,361 patients, including 70 (3%) partially vaccinated and 183 (8%) fully vaccinated. Fully vaccinated patients 18–79 years had a shorter LoS in hospital overall (adjusted hazard ratio for discharge: 1.35, 95%CI: 1.07–1.72), and lower odds of ICU admission (adjusted odds ratio: 0.57, 95%CI: 0.33–0.96). Similar estimates were observed when collectively analysing partially and fully vaccinated patients. We observed no difference in the LoS for patients not admitted to ICU, nor odds of in-hospital death between vaccinated and unvaccinated patients.

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

Conclusions

Vaccinated patients hospitalised with COVID-19 in Norway have a shorter LoS and lower odds of ICU admission than unvaccinated patients. These findings can support patient management and ongoing capacity planning in hospitals.

Keywords: Norway; SARS-CoV-2; hospitalisation; length of stay; intensive care; mRNA vaccine; breakthrough infection

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

Introduction

Ongoing COVID-19 vaccination programmes have drastically reduced the burden of COVID-19 related hospitalisations and deaths (1-5). However, the risk of breakthrough cases of severe COVID-19 after vaccination remains, particularly among groups at higher risk of severe disease (6, 7).

Norway (population 5.4 million) started COVID-19 vaccination on 27 December 2020, initially focusing on individuals ≥65 years, health care workers and individuals at increased risk of severe COVID-19 (8). The mRNA vaccines Comirnaty and Spikevax are the two predominant vaccines administered (9). Vaccination coverage has steadily increased, with national one dose coverage among ≥18-year-olds reaching 91% and two dose coverage 84% by the end of September 2021 (10). Persons with specific immunosuppressive conditions were first offered a third dose in early September 2021 (11). Booster doses have been offered to all persons ≥65 years and care home residents since early October 2021 (12).

With most of the Norwegian population vaccinated, an increasing number and proportion of COVID-19 related hospitalisations are occurring among vaccinated patients, characterised by advanced age and underlying comorbidities that put them at an increased risk of severe COVID-19 (8, 10). It is therefore essential to understand how vaccination may affect clinical endpoints among patients who are admitted to hospital for COVID-19 to support patient management and capacity planning in hospitals. Published data on this are currently limited (13, 14).

We linked individual-level data from national registries to estimate the length of stay (LoS) in hospital (with and without intensive care unit (ICU) stay), and odds of ICU admission and in-hospital mortality among COVID-19 patients ≥18 years in Norway who had been vaccinated with an mRNA vaccine, compared to unvaccinated patients.

Methods

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity. It is made available under a CC-BY-NC-ND 4.0 International license .

Patient cohort

We conducted a cohort study, including patients ≥18 years hospitalised after a positive SARS-CoV-2 test between 1 February and 30 September 2021, and who had a national identity number registered. We included patients hospitalised not more than two days before and less than 28 days following a positive SARS-CoV-2 test, where COVID-19 was reported as the main cause of admission. Cases hospitalised with other or unknown main cause of admission were excluded. We did not restrict admissions by LoS.

Data sources

We obtained data from the Norwegian national emergency preparedness registry for COVID-19 (15). The preparedness registry contains individual-level data covering all residents in Norway, and includes all laboratory-confirmed cases of COVID-19, all hospitalisations and ICU admissions among cases, and COVID-19 vaccinations. Further details on the data sources are presented in supplementary materials A, part 1. We extracted data from the preparedness registry on 22 October 2021, ensuring a minimum of 21 days follow-up since last date of hospitalisation.

Definition of COVID-19 vaccination status

Vaccination status was defined based on the date of positive test for SARS-CoV-2:

1. Unvaccinated: Not vaccinated with a COVID-19 vaccine.
2. Partially vaccinated: Positive test ≥21 days after first dose and <7 days after second dose (if administered).
3. Fully vaccinated: Positive test ≥7 days after second dose with at least the absolute minimum interval between doses depending on the type of vaccine (16), or ≥7 days after first dose if previously diagnosed with a SARS-CoV-2 infection ≥21 days before vaccination.

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

We excluded patients vaccinated with one dose <21 days before positive test, patients vaccinated with a non-mRNA vaccine only and reported reinfections of SARS-CoV-2 among unvaccinated patients.

Outcome measures

We calculated the LoS in hospital (with and without ICU stay) as the time between first admission and last discharge. We did not calculate LoS in ICU separately, due to the small number of vaccinated patients admitted to ICU. For patients with more than one registered hospital stay, we included time between stays in the patient's LoS, if the time between two consecutive stays was <24 hours. Patients with unknown date of discharge from their last stay were considered to still be hospitalised. In-hospital mortality was registered at discharge.

Data analysis

Explanatory variables used to analyse differences in our outcomes were vaccination status, age, sex, county of residence, regional health authority, date of admission, country of birth, virus variant, and underlying risk factors.

To analyse differences in the LoS in hospital, we used a Cox proportional hazards model, with right censoring of patients still admitted to hospital at the end of the study period. Kaplan Meier curves were computed for each explanatory variable univariably, using survfit from the R-package survival. One minus the empirical cumulative negative binomial distribution function was fitted to each Kaplan Meier curve by minimising the sum of squared error, using the function optim in R. The function coxph from the R-package survival was used to compute the hazard ratio (HR) for discharge for each explanatory variable.

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

We used logistic regression to estimate the differences in 1) the proportion of patients admitted to ICU and 2) the proportion of patients who died. For the proportion of patients who died we only included patients who had been discharged.

We ran models for different age groups (18–64 years, 65–79 years, 18–79 years, ≥80 years and ≥18 years) and vaccinated cohorts (fully vaccinated only or fully vaccinated and partially vaccinated together). Partially vaccinated patients were not analysed separately due to small numbers. Multivariable models were obtained by forward model selection and AIC comparison. Vaccination status was maintained in all models regardless of significance. AIC comparison was also used for determining whether age and date of admission were included linearly, with a spline or categorically. Adjusted HR (aHR) and odds-ratios (aOR) were reported.

We conducted sensitivity analyses by changing the definition of our study population, time period of analysis or our outcome definitions to further explore if our main results were robust (supplementary materials A, part 2).

Ethics

Ethical approval for this study was granted by Regional Committees for Medical Research Ethics - South East Norway, reference number 249509. The need for informed consent was waived by the ethics committee.

Results

Description of cohort

During the study period, 2,569 reported cases of COVID-19 were hospitalised with COVID-19 as the main cause of hospitalisation not more than two days before and less than 28 days after a positive SARS-CoV-2 test. Of these, 2,522 (98%) had a national identity number registered. We excluded 154

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity. It is made available under a CC-BY-NC-ND 4.0 International license .

patients vaccinated with one dose <21 days before positive test, five patients vaccinated with non-mRNA vaccines, and one unvaccinated patient who was reported as having been reinfected with SARS-CoV-2. We also dropped one patient who had a reported stay in ICU outside of their hospital stay, due to assumed incomplete reporting on hospital stays.

The remaining 2,361 patients made up our study cohort. Of these, 421 (18%) had been admitted to ICU. At the end of the follow-up period 18 patients (0.8%) were still admitted to hospital. Of the 2,343 patients who had been discharged, 107 died in hospital (4.6%).

Seventy patients (3.0%) were partially vaccinated and 183 (7.8%) fully vaccinated. Most patients received Comirnaty (84% among partially vaccinated, 93% among fully vaccinated). A breakdown of vaccine types is presented in supplementary materials A, part 3, including time between doses for fully vaccinated patients. The median time from last dose to diagnosis was 44 days (interquartile range (IQR): 30–54) for partially vaccinated and 126 days (IQR: 90–186) for fully vaccinated. Age and the frequency of certain underlying risk factors such as cancer, chronic lung disease, heart disease, immunocompromised (due to illness or treatment) and kidney disease increased from unvaccinated to partially vaccinated to fully vaccinated patients. Detailed characteristics of the study cohort by vaccination status are presented in Table 1.

Length of stay in hospital, and odds of admission to intensive care and in-hospital death by vaccination status

After adjusting for all explanatory variables, results suggested that fully vaccinated patients aged ≥18 years had a shorter LoS in hospital overall (aHR for discharge: 1.40, 95%CI: 1.14–1.71) (Fig 1, Table 2), and lower odds of ICU admission (aOR: 0.60, 95%CI: 0.39–0.91) compared to unvaccinated patients (Fig 1, Table 3). This was driven by the age group 18–79 years (aHR for discharge: 1.35, 95%CI: 1.07–1.72; aOR for ICU admission: 0.57, 95%CI: 0.33–0.96). When the analysis was restricted to only patients not admitted to ICU, we did not observe a difference in the LoS for fully vaccinated patients,

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

compared to unvaccinated patients. Similar estimates were observed when collectively comparing partially and fully vaccinated patients to unvaccinated patients (Table 2, Table 3). Estimates for patients 18–64 and 65–79 years tended in the same direction as patients 18–79 years, but statistical significance in adjusted models was only observed for the LoS in hospital (18–64) and odds of ICU admission (65–79) when including partially vaccinated patients. Among patients ≥80 years, adjusted estimates tended towards a shorter LoS, but for all outcomes results were not statistically significant (Table 2, Table 3). There was no difference in the adjusted odds of in-hospital death between vaccinated and unvaccinated patients in any age group (Table 3). Our results were robust in sensitivity analyses, although one notable difference was fully vaccinated patients ≥80 years having lower odds of in-hospital death (aOR: 0.24, 95%CI: 0.09–0.56) when including all SARS-CoV-2 positive patients, regardless of main cause of hospitalisation (supplementary materials A, part 2).

Estimates from all univariable and multivariable models are presented in supplementary materials B, C and D.

Discussion

In this national register-based study, we have analysed individual-level data on 2,361 hospitalised COVID-19 patients, during a period when mRNA vaccines were the predominant vaccines administered using a two-dose schedule. In line with other reports (7, 13, 14, 17), vaccinated patients were generally older and had a higher prevalence of underlying risk factors than unvaccinated patients.

Our results suggest that COVID-19 patients aged 18–79 years in Norway who had been vaccinated with an mRNA vaccine had 43% lower odds of ICU admission and a shorter LoS in hospital than unvaccinated patients. Assuming exponential distribution of the survival data, an aHR for discharge of 1.35 translates into an average 26% decrease in LoS for fully vaccinated patients (1 - 1/1.35) (18). We did not observe a statistically significant difference in the LoS for vaccinated patients not

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

admitted to ICU. Estimates for this parameter may have been affected by vaccinated patients who would have ended up in ICU if unvaccinated instead spending more time in regular hospital wards, although point estimates tended towards a shorter LoS among vaccinated patients in some age groups, with one sensitivity analysis including partially and fully vaccinated patients 18–79 years statistically significant. Results for patients 18–64 and 65–79 years, as well as LoS for patients ≥80 years tended in the same direction, but may have been limited by small sample sizes. Vaccination did not reduce the odds of in-hospital death. The exception was patients ≥80 years in a sensitivity analysis including all SARS-CoV-2 positive patients, regardless of main cause of hospitalisation. For unvaccinated patients with another main cause of hospitalisation, COVID-19 may have been a more significant contributing factor for admission, while frail elderly patients with multiple comorbidities may be more likely to be unvaccinated.

Our results suggest that once hospitalised the risk of death among vaccinated and unvaccinated patients in Norway is similar. However, for survivors the disease trajectory is milder in vaccinated patients, with reduced need for hospital care and organ support. With vaccination coverage steadily increasing around the world, these findings have important implications for patient management and ongoing capacity planning in hospitals. A study including 142 patients fully vaccinated with an mRNA vaccine from 21 sites across the United States also reported a shorter LoS, lower odds of death or invasive mechanical ventilation and a lower level of clinical disease severity among vaccinated patients (13). In contrast, a study from Michigan, United States did not find lower odds of ICU admission, mechanical ventilation or death when comparing 825 partially vaccinated or 129 fully vaccinated patients (vaccinated with Comirnaty, Spikevax or Janssen) to unvaccinated patients (14). Differences in the study cohorts, setting and design need to be considered, and there is a clear need for more research from a range of different settings to further explore and build on the observed findings, particularly as vaccination programmes continue to evolve. While studies have suggested sustained high effectiveness of mRNA vaccines against hospitalisation at least six months following vaccination (19, 20), the duration of protection following the original two-dose schedules for mRNA

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity. It is made available under a CC-BY-NC-ND 4.0 International license .

vaccines and the effects of booster doses beyond the original schedules (12, 21-23) require ongoing research.

Our results highlight that other factors continue to influence patient outcomes despite vaccination, with a longer LoS and/or increased odds of ICU admission or death associated with advanced age, male sex and certain risk factors such as immunosuppression, kidney disease, obesity, diabetes and heart disease, as reported by others (24-27).

A strength of our study is that all data sources had national coverage. Also, hospitals in Norway functioned within capacity during the study period, while criteria for hospitalisation and isolation were consistent and not related to vaccination status. Although we did not have access to treatment data, there were no major changes in treatment guidelines for COVID-19 patients in hospital or ICU during the study period in Norway. We also had minimal censoring of the study cohort, with 0.8% of patients still admitted to hospital at the end of follow-up.

Our study also has limitations. While we have controlled for several important confounders, the potential for residual confounding must be acknowledged, given the observational nature of the study. Also, the small number of vaccinated patients in some analyses must be considered, and we were not yet able to conduct more detailed analyses of different vaccine parameters, such as vaccine type, time since vaccination and dose intervals. However, our results were robust when we restricted our analysis to vaccinated patients with no more than 150 days between date of last dose and positive test. Another limitation is that some of our reported underlying risk factors do not distinguish potential differences within groups, for example whether risk factors are well-regulated or treated. Also, 38% of patients had unknown body mass index. Our model may therefore not fully adjust for certain underlying risk factors. We were also not able to adjust for care home residents, who may receive healthcare for severe COVID-19 partially or fully outside a hospital setting. This is particularly relevant for our cohort of patients ≥80 years. Finally, previous natural infection is associated with a high level of protection against SARS-CoV-2 reinfection (28, 29), and while we

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

dropped one reported reinfection, we cannot rule out that there were other previously undiagnosed SARS-CoV-2 infections in our unvaccinated cohort. If present, this would bias the association between vaccination and our outcomes towards the null.

Our study suggests that mRNA vaccinated patients hospitalised with COVID-19 in Norway have a shorter LoS and lower odds of ICU admission than unvaccinated patients. These findings can support patient management and ongoing capacity planning in hospitals and underline the importance of vaccination programmes against COVID-19.

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

Transparency declaration

Authors' contributions

RW, ABK, BVS, ES, RK and EAB conceived the idea for the study. RW drafted the study protocol and coordinated the study. RK and EAB contributed directly to the acquisition of data. RW and ABK contributed to data cleaning, validation and preparation. RW and ABK led the data analysis. All co-authors contributed to the interpretation of the results. RW and ABK drafted the manuscript. All co-authors contributed to the revision of the manuscript and approved the final version for submission.

Conflict of interest

The authors declare that they have no competing interests.

Funding

The authors received no specific funding for this work.

Acknowledgements

First and foremost, we wish to thank all those who have helped establish, coordinate and report data to the national emergency preparedness registry at the Norwegian Institute of Public Health (NIPH) throughout the pandemic. We also highly acknowledge the efforts of staff at hospitals around Norway to ensure the reporting of timely and complete data to the Norwegian Intensive Care and Pandemic Registry, as well as colleagues at the register itself. We would like to specifically thank Trude Marie Lyngstad, Jostein Starrfelt, Håkon Bøås and Lamprini Veneti at the NIPH for their assistance in cleaning the data from different registries.

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

Access to data

The dataset analysed in the study contains individual-level linked data from various central health registries, national clinical registries and other national administrative registries in Norway. The researchers had access to the data through the national emergency preparedness registry for COVID-19 (Beredt C19), housed at the Norwegian Institute of Public Health (NIPH). In Beredt C19, only fully anonymised data (i.e. data that are neither directly nor potentially indirectly identifiable) are permitted to be shared publicly. Legal restrictions therefore prevent the researchers from publicly sharing the dataset used in the study that would enable others to replicate the study findings. However, external researchers are freely able to request access to linked data from the same registries from outside the structure of Beredt C19, as per normal procedure for conducting health research on registry data in Norway. Further information on Beredt C19, including contact information for the Beredt C19 project manager, and information on access to data from each individual data source, is available at https://www.fhi.no/en/id/infectious-diseases/coronavirus/emergency-preparedness-register-for-covid-19/.

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

References

1. Lopez Bernal J, Andrews N, Gower C, Gallagher E, Simmons R, Thelwall S, et al. Effectiveness of Covid-19 Vaccines against the B.1.617.2 (Delta) Variant. N Engl J Med. 2021;385(7):585-94.

2. Vasileiou E, Simpson CR, Shi T, Kerr S, Agrawal U, Akbari A, et al. Interim findings from first-dose mass COVID-19 vaccination roll-out and COVID-19 hospital admissions in Scotland: a national prospective cohort study. Lancet. 2021;397(10285):1646-57.

3. Tenforde MW, Patel MM, Ginde AA, Douin DJ, Talbot HK, Casey JD, et al. Effectiveness of SARS-CoV-2 mRNA Vaccines for Preventing Covid-19 Hospitalizations in the United States. Clin Infect Dis. 2021.

4. Haas EJ, Angulo FJ, McLaughlin JM, Anis E, Singer SR, Khan F, 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. Lancet. 2021;397(10287):1819-29.

5. Glatman-Freedman A, Bromberg M, Dichtiar R, Hershkovitz Y, Keinan-Boker L. The BNT162b2 vaccine effectiveness against new COVID-19 cases and complications of breakthrough cases: A nation-wide retrospective longitudinal multiple cohort analysis using individualised data. EBioMedicine. 2021;72:103574.

6. Hippisley-Cox J, Coupland CA, Mehta N, Keogh RH, Diaz-Ordaz K, Khunti K, et al. Risk prediction of covid-19 related death and hospital admission in adults after covid-19 vaccination: national prospective cohort study. BMJ. 2021;374:n2244.

7. Brosh-Nissimov T, Orenbuch-Harroch E, Chowers M, Elbaz M, Nesher L, Stein M, et al. BNT162b2 vaccine breakthrough: clinical characteristics of 152 fully vaccinated hospitalized COVID-19 patients in Israel. Clin Microbiol Infect. 2021.

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity. It is made available under a CC-BY-NC-ND 4.0 International license .

298 8. Norwegian Institute of Public Health. Who will get the coronavirus vaccine? 2021 [cited 2021
299 Nov 4]. Available from: https://www.fhi.no/en/id/vaccines/coronavirus-immunisation-
300 programme/who-will-get-coronavirus-vaccine-first/

301 9. Norwegian Institute of Public Health. Coronavirus vaccine - information for the public. 2021
302 [cited 2021 Nov 4]. Available from: https://www.fhi.no/en/id/vaccines/coronavirus-immunisation-
303 programme/who-will-get-coronavirus-vaccine-first/

304 10. Norwegian Institute of Public Health. Ukerapporter om koronavirus og covid-19. Oslo:
305 Norwegian Institute of Public Health. 2021 [cited 2021 Nov 4]. Available from:
306 https://www.fhi.no/publ/2020/koronavirus-ukerapporter/

307 11. Norwegian Institute of Public Health. Personer med nedsatt immunforsvar anbefales en
308 tredje vaksinedose. Oslo: Norwegian Institute of Public Health. 2021 [cited 2021 Nov 4]. Available
309 from: https://www.fhi.no/nyheter/2021/personer-med-nedsatt-immunforsvar-anbefales-en-tredje-
310 vaksinedose/

311 12. Norwegian Institute of Public Health. Oppfriskningsdose til eldre og sykehjemsbeboere. 2021
312 [cited 2021 Nov 4]. Available from: https://www.fhi.no/nyheter/2021/personer-med-nedsatt-
313 immunforsvar-anbefales-en-tredje-vaksinedose/

314 13. Tenforde MW, Self WH, Adams K, Gaglani M, Ginde AA, McNeal T, Ghamande S, et al.
315 Association Between mRNA Vaccination and COVID-19 Hospitalization and Disease Severity. JAMA.
316 2021. doi: 10.1001/jama.2021.19499.

317 14. Bahl A, Johnson S, Maine G, Garcia MH, Nimmagadda S, Qu L, et al. Vaccination reduces need
318 for emergency care in breakthrough COVID-19 infections: A multicenter cohort study. Lancet Reg
319 Health Am. 2021:100065.

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

15. Norwegian Institute of Public Health. Emergency preparedness register for COVID-19 (Beredt C19). 2021 [cited 2021 Nov 4]. Available from: https://www.fhi.no/en/id/infectious-diseases/coronavirus/emergency-preparedness-register-for-covid-19/

16. Norwegian Institute of Public Health. Vanlige problemstillinger om koronasertifikat. 2021 [cited 2021 Nov 4]. Available from: https://www.fhi.no/en/id/infectious-diseases/coronavirus/emergency-preparedness-register-for-covid-19/

17. Agrawal U, Katikireddi SV, McCowan C, Mulholland RH, Azcoaga-Lorenzo A, Amele S, et al. COVID-19 hospital admissions and deaths after BNT162b2 and ChAdOx1 nCoV-19 vaccinations in 2.57 million people in Scotland (EAVE II): a prospective cohort study. Lancet Respir Med. 2021.

18. Barraclough H, Simms L, Govindan R. Biostatistics primer: what a clinician ought to know: hazard ratios. J Thorac Oncol. 2011;6(6):978-82.

19. Chemaitelly H, Yassine HM, Benslimane FM, Al Khatib HA, Tang P, Hasan MR, et al. mRNA-1273 COVID-19 vaccine effectiveness against the B.1.1.7 and B.1.351 variants and severe COVID-19 disease in Qatar. Nat Med. 2021;27(9):1614-21.

20. Tartof SY, Slezak JM, Fischer H, Hong V, Ackerson BK, Ranasinghe ON, et al. Effectiveness of mRNA BNT162b2 COVID-19 vaccine up to 6 months in a large integrated health system in the USA: a retrospective cohort study. Lancet. 2021;398(10309):1407-16.

21. Danish Health Authority. Vedr. revaccination mod COVID-19. 2021 [cited 2021 Nov 4]. Available from: https://www.sst.dk/-/media/Udgivelser/2021/Corona/Vaccination/Revaccination/Vedr-revaccination-mod-COVID-19-280921.ashx?la=da&hash=8F220749B81743A9CC35C3715CB1409CCF26FB5C

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

341 22. Public Health England. COVID-19 vaccination: a guide to booster vaccination. 2021 [cited
342 2021 Nov 4]. Available from: https://www.gov.uk/government/publications/covid-19-vaccination-
343 booster-dose-resources/covid-19-vaccination-a-guide-to-booster-vaccination.

344 23. Bar-On YM, Goldberg Y, Mandel M, Bodenheimer O, Freedman L, Kalkstein N, et al.
345 Protection of BNT162b2 Vaccine Booster against Covid-19 in Israel. N Engl J Med. 2021.

346 24. Suarez-Garcia I, Perales-Fraile I, Gonzalez-Garcia A, Munoz-Blanco A, Manzano L, Fabregate
347 M, et al. In-hospital mortality among immunosuppressed patients with COVID-19: Analysis from a
348 national cohort in Spain. PLoS One. 2021;16(8):e0255524.

349 25. Boelle PY, Delory T, Maynadier X, Janssen C, Piarroux R, Pichenot M, et al. Trajectories of
350 Hospitalization in COVID-19 Patients: An Observational Study in France. J Clin Med. 2020;9(10).

351 26. Petrilli CM, Jones SA, Yang J, Rajagopalan H, O'Donnell L, Chernyak Y, et al. Factors associated
352 with hospital admission and critical illness among 5279 people with coronavirus disease 2019 in New
353 York City: prospective cohort study. BMJ. 2020;369:m1966.

354 27. Sjogren L, Stenberg E, Thuccani M, Martikainen J, Rylander C, Wallenius V, et al. Impact of
355 obesity on intensive care outcomes in patients with COVID-19 in Sweden-A cohort study. PLoS One.
356 2021;16(10):e0257891.

357 28. Hall VJ, Foulkes S, Saei A, Andrews N, Oguti B, Charlett A, et al. COVID-19 vaccine coverage in
358 health-care workers in England and effectiveness of BNT162b2 mRNA vaccine against infection
359 (SIREN): a prospective, multicentre, cohort study. Lancet. 2021;397(10286):1725-35.

360 29. Hansen CH, Michlmayr D, Gubbels SM, Molbak K, Ethelberg S. Assessment of protection
361 against reinfection with SARS-CoV-2 among 4 million PCR-tested individuals in Denmark in 2020: a
362 population-level observational study. Lancet. 2021;397(10280):1204-12.

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity. It is made available under a CC-BY-NC-ND 4.0 International license .

Tables and figures

Table 1. Characteristics of SARS-CoV-2 positive patients aged ≥18 years hospitalised with COVID-19 as the main cause of hospitalisation, by vaccination status, Norway, 1 February – 30 September 2021

Characteristics		Vaccination status		
		Unvaccinated (n=2,108)	Partially vaccinated (n=70)	Fully vaccinated (n=183)
Sex	Male	1274 (60.4%)	34 (48.6%)	108 (59.0%)
	Female	834 (39.6%)	36 (51.4%)	75 (41.0%)
			p = 0.046	p = 0.706
Age group	18-29 years	134 (6.4%)	9 (12.9%)	1 (0.5%)
	30-44 years	525 (24.9%)	10 (14.3%)	11 (6.0%)
	45-54 years	572 (27.1%)	14 (20.0%)	19 (10.4%)
	55-64 years	447 (21.2%)	10 (14.3%)	19 (10.4%)
	65-79 years	379 (18.0%)	23 (32.9%)	59 (32.2%)
	≥80 years	51 (2.4%)	4 (5.7%)	74 (40.4%)
			p = 0.001	p < 0.001
Median age	In years (IQR)	51 (41–61)	57,5 (44–72)	77 (61–83)
			p = 0.020	p = <0.001
Born in Norway	Yes, with at least one parent born in Norway	871 (41.3%)	33 (47.1%)	129 (70.5%)
	Yes, two parents born outside of Norway	51 (2.4%)	2 (2.9%)	2 (1.1%)
	No	1129 (53.6%)	28 (40.0%)	39 (21.3%)

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity. It is made available under a CC-BY-NC-ND 4.0 International license .

	Unknown	57 (2.7%)	7 (10.0%)	13 (7.1%)
			p = 0.002	p < 0.001
Underlying risk factors	Asthma	243 (11.5%)	4 (5.7%)	16 (8.7%)
	Cancer [a]	58 (2.8%)	6 (8.6%)	23 (12.6%)
	Chronic lung disease, excluding asthma	112 (5.3%)	8 (11.4%)	36 (19.7%)
	Chronic neurological or neuromuscular disease	76 (3.6%)	5 (7.1%)	16 (8.7%)
	Diabetes (type 1 and 2)	304 (14.4%)	8 (11.4%)	44 (24.0%)
	Heart disease, including hypertension	575 (27.3%)	31 (44.3%)	111 (60.7%)
	Immunocompromised, including HIV and immunosuppressive treatment [b]	55 (2.6%)	6 (8.6%)	31 (16.9%)
	Kidney disease, including kidney failure	60 (2.8%)	7 (10.0%)	34 (18.6%)
	Liver disease, including liver failure	19 (0.9%)	2 (2.9%)	4 (2.2%)
	BMI ≥30 [c]	502 (23.8%)	15 (21.4%)	23 (12.6%)
	Pregnant	48 (2.3%)	0 (0.0%)	1 (0.5%)
	Current smoker	89 (4.2%)	6 (8.6%)	7 (3.8%)
			p = 0.629	p < 0.001
Virus variant	Alpha	1034 (49.1%)	17 (24.3%)	12 (6.6%)
	Beta	22 (1.0%)	0 (0.0%)	1 (0.5%)
	Delta	186 (8.8%)	32 (45.7%)	78 (42.6%)

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity. It is made available under a CC-BY-NC-ND 4.0 International license .

	Non-VOC	41 (1.9%)	2 (2.9%)	7 (3.8%)
	Uncategorised [d]	58 (2.8%)	0 (0.0%)	2 (1.1%)
	Unknown	767 (36.4%)	19 (27.1%)	83 (45.4%)
			p < 0.001	p < 0.001
Month of admission	February	197 (9.3%)	0 (0.0%)	0 (0.0%)
	March	733 (34.8%)	4 (5.7%)	6 (3.3%)
	April	559 (26.5%)	5 (7.1%)	9 (4.9%)
	May	201 (9.5%)	10 (14.3%)	3 (1.6%)
	June	96 (4.6%)	7 (10.0%)	4 (2.2%)
	July	48 (2.3%)	2 (2.9%)	11 (6.0%)
	August	113 (5.4%)	28 (40.0%)	44 (24.0%)
	September	161 (7.6%)	14 (20.0%)	106 (57.9%)
			p < 0.001	p < 0.001
Regional health authority	South-East	1705 (80.9%)	45 (64.3%)	132 (72.1%)
	West	230 (10.9%)	13 (18.6%)	16 (8.7%)
	Mid	98 (4.6%)	9 (12.9%)	24 (13.1%)
	North	75 (3.6%)	3 (4.3%)	11 (6.0%)
			p = 0.002	p < 0.001
Admission to ICU	No	1720 (81.6%)	62 (88.6%)	158 (86.3%)
	Yes	388 (18.4%)	8 (11.4%)	25 (13.7%)
			p = 0.136	p = 0.109
Mortality [e]	Died in ICU	52 (2.5%)	2 (2.9%)	12 (6.7%)
	Died in hospital, not in ICU	26 (1.2%)	5 (7.3%)	10 (5.6%)

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity. It is made available under a CC-BY-NC-ND 4.0 International license .

	Alive at discharge	2017 (96.3%)	62 (89.9%)	157 (87.7%)
			p < 0.001	p < 0.001
Number of patients still in hospital at end of follow-up (21 October 2021)	In ICU	6 (0.3%)	0 (0.0%)	2 (1.1%)
	In hospital, not in ICU	7 (0.3%)	1 (1.4%)	2 (1.1%)
	Discharged from hospital	2095 (99.4%)	69 (98.6%)	179 (97.8%)
			p = 0.298	p = 0.059

IQR: interquartile range; VOC: Variant of concern; ICU: Intensive care unit; BMI: Body mass index. P values compared to unvaccinated calculated using chi-squared tests or Wilcoxon rank sum tests as appropriate. P values for underlying risk factors based on proportion having any one of the listed risk factors.

[a] Refers to cancer patients undergoing treatment or with regular controls (>1 per year).

[b] Includes ongoing use of steroids in doses equivalent to at least 5mg Prednisolone daily.

[c] In our dataset, 898 patients (38%) had unknown information on height and weight, and thus unknown data on BMI. Of these 898, 801 were unvaccinated (38% of all unvaccinated), 28 partially vaccinated (40%) and 69 fully vaccinated (38%). In our models, BMI was therefore included as a three-level categorical variable, yes, no and unknown.

[d] Cases for which VOC and non-VOC could not clearly be distinguished based on the available information.

[e] Excludes patients still in hospital at end of follow-up.

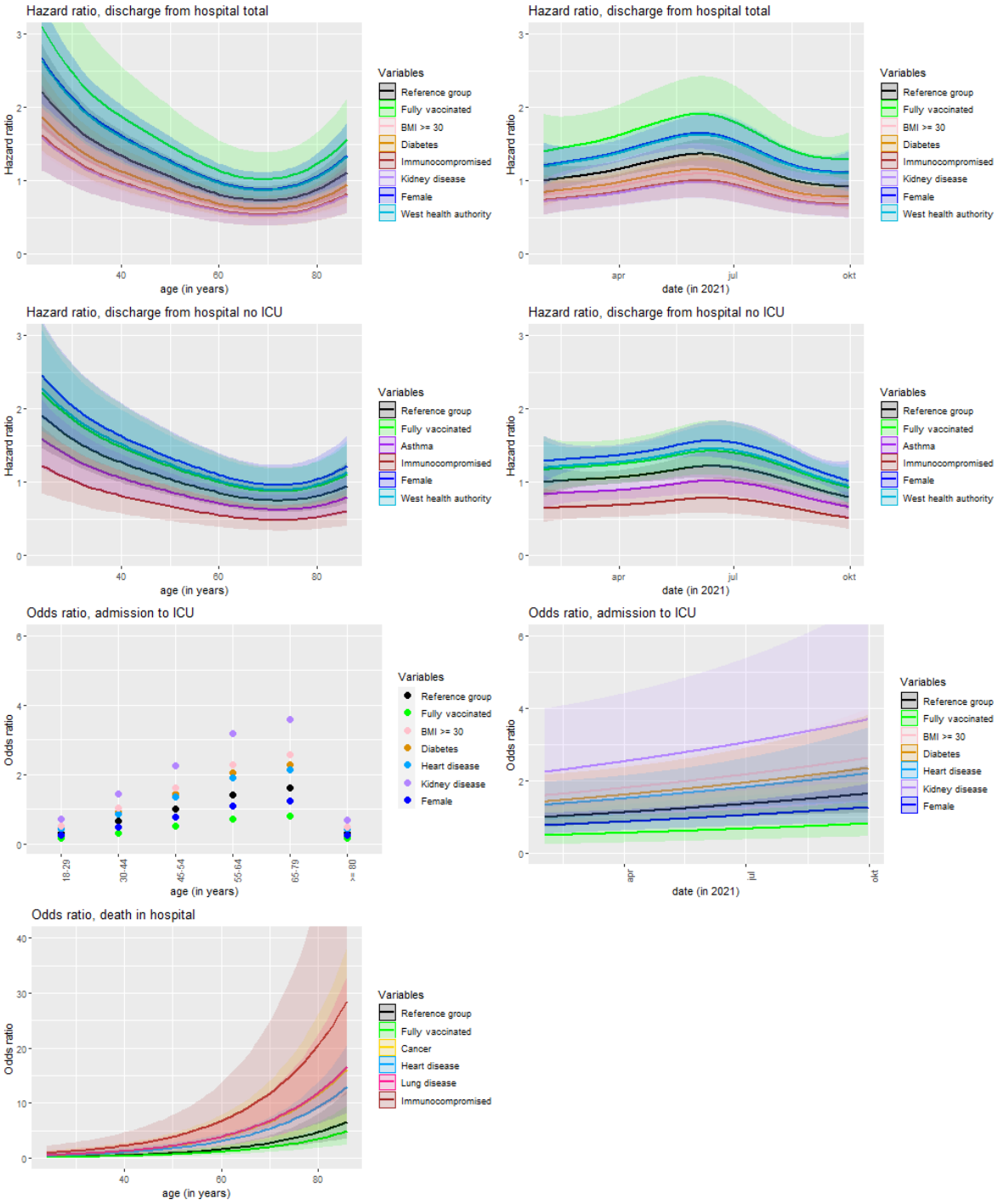
medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

376 *Figure 1. Adjusted hazard ratios for discharge from hospital (with and without stay in intensive care),*

377 *and adjusted odds ratios for admission to intensive care and in-hospital mortality, SARS-CoV-2*

378 *positive patients aged ≥18 years hospitalised with COVID-19 as the main cause of hospitalisation, by*

379 *age or date of admission, Norway, 1 February – 30 September 2021*



380

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint
(which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity.
It is made available under a CC-BY-NC-ND 4.0 International license .

ICU: Intensive care unit. The reference group with a hazard ratio or odds ratio = 1 is patients who are male, aged 52 years (median age in dataset) or age group 45–54 years, born in Norway with at least one parent born in Norway, without underlying risk factors, unvaccinated and admitted to hospital on 1 February 2021. Hazard ratios were calculated using a Cox proportional hazards model, and odds ratios using logistic regression. The variables shown in each panel are those significantly associated with each outcome in multivariable models (see supplementary materials D). AIC comparison was used for determining whether age and date of admission were included linearly, with a spline or categorically. No panel for death in hospital by date of admission is shown, as date of admission was not associated death in hospital in our multivariable model (see supplementary materials D).

388 *Table 2. Length of stay in hospital and crude and adjusted hazard ratios for discharge from hospital (with and without stay in intensive care) from a Cox*

389 *proportional hazards model, SARS-CoV-2 positive patients aged ≥18 years hospitalised with COVID-19 as the main cause of hospitalisation, by vaccination*

390 *status and age group, Norway, 1 February – 30 September 2021*

		Vaccination status									
		Unvaccinated		Fully vaccinated				Partially and fully vaccinated			
Age group	Outcome	Number of patients	Median (IQR) [a]	Number of patients	Median (IQR) [a]	Crude hazard ratio for discharge compared to unvaccinated (95%CI)	Adjusted [b] hazard ratio for discharge compared to unvaccinated (95%CI)	Number of patients	Median (IQR) [a]	Crude hazard ratio for discharge compared to unvaccinated (95%CI)	Adjusted [b] hazard ratio for discharge compared to unvaccinated (95%CI)
18–64 years	Days in hospital including patients admitted to ICU	1678	4.7 (2.5–8.5)	50	4.0 (2.7–11.2)	0.832 (0.624–1.109)	1.217 (0.879–1.686)	93	3.7 (1.6–7.1)	1.095 (0.885–1.354)	**1.374 (1.075–1.757)**
	Days in hospital for patients not admitted to ICU	1401	3.9 (2.0–6.4)	40	3.8 (2.1–6.8)	0.880 (0.642–1.206)	0.987 (0.714–1.365)	80	2.8 (1.5–5.6)	1.118 (0.890–1.403)	0.717 (0.360–1.32
65–79 years	Days in hospital including patients admitted to ICU	379	7.1 (3.8–14.6)	59	6.9 (3.6–12.8)	1.159 (0.875–1.534)	1.241 (0.932–1.652)	82	7.0 (3.8–14.1)	1.059 (0.832–1.350)	1.172 (0.877–1.43
	Days in hospital for patients not admitted to ICU	271	4.9 (2.9–8.3)	49	5.7 (3.0–9.5)	0.846 (0.622–1.151)	1.315 (0.863–2.003)	68	5.8 (3.2–9.6)	0.780 (0.596–1.022)	1.152 (0.801–1.62
18–79 years	Days in hospital including patients admitted to ICU	2057	5.0 (2.6–9.2)	109	6.0 (3.0–11.9)	0.845 (0.694–1.028)	**1.353 (1.067–1.715)**	175	5.0 (2.1–10.5)	0.935 (0.799–1.093)	**1.377 (1.145–1.657)**
	Days in hospital for patients not admitted to ICU	1672	4.0 (2.1–6.7)	89	4.6 (2.8–8.9)	**0.733 (0.591–0.909)**	0.831 (0.651–1.061)	148	4.0 (2.0–7.7)	**0.802 (0.676–0.951)**	1.122 (0.917–1.373
≥80 years	Days in hospital including	51	5.7	74	3.5	1.283	1.174	78	3.8	1.232	1.139

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity. It is made available under a CC BY-NC-ND 4.0 International license.

	patients admitted to ICU		(2.9–8.0)		(1.9–8.3)	(0.894–1.842)	(0.809–1.705)		(1.9–8.5)	(0.861–1.763)	(0.787–1.650)
	Days in hospital for patients not admitted to ICU	48	5.2 (2.8–7.4)	69	3.2 (1.8–6.9)	1.200 (0.827–1.741)	1.184 (0.812–1.725)	72	3.4 (1.8–7.1)	1.163 (0.805–1.681)	1.115 (0.765–1.624)
≥18 years	Days in hospital including patients admitted to ICU	2108	5.0 (2.6–9.2)	183	4.9 (2.6–9.8)	1.007 (0.865–1.174)	**1.398 (1.139–1.717)**	253	4.6 (2.1–9.6)	1.030 (0.903–1.175)	**1.307 (1.100–1.551)**
	Days in hospital for patients not admitted to ICU	1720	4,0 (2.1–6.7)	158	4.0 (2.1–8.1)	**0.840 (0.713–0.990)**	1.168 (0.938–1.453)	220	3.9 (1.9–7.4)	**0.859 (0.745–0.990)**	1.178 (0.937–1.368)

ICU: Intensive care unit; IQR: Interquartile range; 95%CI: 95% confidence interval. Bold text = statistically significant results.

[a] 13 unvaccinated, 1 partially vaccinated and 4 fully vaccinated patients were still admitted to hospital at the end of the follow-up period. These patients are included in the calculated medians and IQR, and adjusted for in the Cox proportional hazards model using right censoring.

[b] Adjusted for age, sex, county of residence, regional health authority, date of admission, country of birth, virus variant and underlying risk factors. The variables included in the final multivariable model were obtained by forward model selection and AIC comparison (see supplementary materials D).

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity. It is made available under a CC-BY-NC-ND 4.0 International license .

396 *Table 3. Crude and adjusted odds ratios for admission to intensive care and in-hospital mortality from logistic regression, SARS-CoV-2 positive patients aged*

397 *≥18 years hospitalised with COVID-19 as the main cause of hospitalisation, by vaccination status and age group, Norway, 1 February – 30 September 2021*

		Vaccination status									
		Unvaccinated		Fully vaccinated				Partially and fully vaccinated			
Age group	Outcome	No (%)	Yes (%)	No (%)	Yes (%)	Crude odds ratio compared to unvaccinated (95%CI)	Adjusted [b] odds ratio compared to unvaccinated (95%CI)	No (%)	Yes (%)	Crude odds ratio compared to unvaccinated (95%CI)	Adjusted [b] odds ratio compared to unvaccinated (95%CI)
18–64 years	Admission to ICU	1401 (83%)	277 (17%)	40 (80%)	10 (20%)	1.264 (0.625–2.559)	0.946 (0.412–1.975)	80 (86%)	13 (14%)	0.822 (0.451–1.498)	0.717 (0.360–1.323)
	Death in hospital [a]	1641 (98%)	31 (2%)	42 (87.5%)	6 (12.5%)	**7.562 (2.995–19.095)**	2.568 (0.760–7.433)	83 (92%)	7 (8%)	**4.464 (1.909–10.438)**	1.599 (0.512–4.316)
65–79 years	Admission to ICU	271 (71.5%)	108 (28.5%)	49 (83%)	10 (17%)	0.512 (0.250–1.048)	0.512 (0.237–1.007)	68 (83%)	14 (17%)	**0.517 (0.279–0.957)**	**0.455 (0.201–0.988)**
	Death in hospital [a]	335 (90%)	37 (10%)	50 (88%)	7 (12%)	1.268 (0.536–2.998)	1.297 (0.505–2.928)	69 (86%)	11 (14%)	1.443 (0.702–2.969)	1.480 (0.685–2.982)
18–79 years	Admission to ICU	1672 (81%)	385 (19%)	89 (82%)	20 (18%)	0.976 (0.593–1.605)	**0.571 (0.326–0.955)**	148 (85%)	27 (15%)	0.792 (0.518–1.212)	**0.516 (0.321–0.802)**
	Death in hospital [a]	1976 (97%)	68 (3%)	92 (88%)	13 (12%)	**4.106 (2.189–7.702)**	1.234 (0.596–2.393)	152 (89%)	18 (11%)	**3.441 (1.995–5.935)**	1.174 (0.621–2.124)
≥80 years	Admission to ICU	48 (94%)	3 (6%)	69 (93%)	5 (7%)	1.159 (0.264–5.083)	1.889 (0.366–12.300)	72 (92%)	6 (8%)	1.333 (0.318–5.590)	2.156 (0.453–13.475)

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity. It is made available under a CC-BY-NC-ND 4.0 International license .

	Death in hospital [a]	41 (80%)	10 (20%)	65 (88%)	9 (12%)	0.568 (0.213–1.515)	0.588 (0.206–1.658)	67 (86%)	11 (14%)	0.673 (0.263–1.724)	0.720 (0.269–1.948)
≥18 years	Admission to ICU	1720 (81%)	388 (18%)	158 (86%)	25 (14%)	0.701 (0.454–1.085)	**0.497 (0.281–0.857)**	220 (87%)	33 (13%)	**0.665 (0.454–0.974)**	**0.600 (0.387–0.908)**
	Death in hospital [a]	2017 (96%)	78 (4%)	157 (88%)	22 (12%)	**3.624 (2.197–5.976)**	0.741 (0.402–1.322)	219 (88%)	29 (12%)	**3.424 (2.187–5.362)**	0.842 (0.488–1.422)

ICU: Intensive care unit; 95%CI: 95% confidence interval. Bold text = statistically significant results.

[a] Excludes patients who were still admitted to hospital at the end of the study period.

[b] Adjusted for age, sex, county of residence, regional health authority, date of admission, country of birth, virus variant and underlying risk factors. The variables included in the final multivariable model were obtained by forward model selection and AIC comparison (see supplementary materials D).

medRxiv preprint doi: https://doi.org/10.1101/2021.11.05.21265958; this version posted November 9, 2021. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted medRxiv a license to display the preprint in perpetuity. It is made available under a CC-BY-NC-ND 4.0 International license .