Preventive Medicine Reports 32 (2023) 102152

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Short communication

COVID-19 vaccination decreased COVID-19 hospital length of stay, in-hospital death, and increased home discharge

Se Won Lee *, Danny Ma, Adrian Davoodian, Napatkamon Ayutyanont, Bryan Werner

Sunrise Health GME Consortium, HCA Healthcare, Las Vegas, NV, United States

ARTICLE INFO

Keywords:
COVID-19
Vaccination
Age
In-hospital mortality
Length of stay
Home discharge

ABSTRACT

COVID-19 vaccination impact on hospital outcome metrics among patients hospitalized with COVID-19 is not well known. We evaluated if covid-19 vaccination was associated with better hospital outcomes such as in-hospital mortality, overall length of stay, and home discharge.

This retrospective study analyzed data from the electronic health records of 29,732 patients admitted with COVID-19 with or without vaccination (21,525 unvaccinated and 8207 vaccinated) from January to December 2021.

The association of COVID-19 vaccination status with overall length of hospitalization, in-hospital mortality rate, home discharge after hospitalization was investigated using a multivariate logistic regression and a generalized linear model.

The mean age of all groups was 58.16 ± 17.39 years. The unvaccinated group was younger (54.95 ± 16.75) and had less comorbidities compared to the vaccinated group. Patients that had received COVID-19 vaccination exhibited decreased in-hospital mortality (OR 0.666, 95 % CI 0.580–0.764), decreased length of stay (−2.13 days, CI 2.73–1.55 days), and increased rate of home discharge (OR 1.168, CI 1.037–1.315). Older age and cerebrovascular accident diagnosis at admission demonstrated a negative effect on hospital outcomes with decreased home discharge (OR 0.950 per 1 year, CI 0.946–0.953 and OR 0.415, CI 0.202–0.854) and increased inhospital mortality (OR 1.04 per 1 year, CI 1.036–1.045 and OR 3.005, CI 1.961–4.604).

This study shows the additional positive impact of COVID-19 vaccination has not just on in-hospital mortality but also in reducing overall length of stay and improved hospital outcome metrics including increasing likelihood of home discharge after hospitalization.

The novel coronavirus pandemic (known as COVID-19) caused by SARS COV-2 virus has infected 87 million people in the United States, with more than a million fatalities as of June 2022.(Proportions, 2022) The pandemic has inflicted a tremendous burden on both indviduals and the the entire healthcare system. The issue will not likely go away any time soon as there continues to be outbreaks despite vaccination and other ongoing mitigation efforts (Sen et al., 2021).

COVID vaccination has already proven to be effective against hospital admission and development of severe-critical disease.(Sadoff et al., 2022) However, it is still staggering among vulnerable populations including Black and Hispanic/Latinos.(Kirson et al., 2022; Sparks et al., 2022) Loosening other preventive measures such as social distance and mask mandate may necessitate more effort to ramp up vaccination rates, however, vaccination rates have plateaued.(Lam et al., 2021) More information and education on the broader benefit of COVID-19 vaccination may help to increase the rate of vaccination. In addition, the changing demographics of patients hospitalized with COVID-19 and the evolving risk factors for poor hospital outcomes in the era of COVID-19 vaccination have not been thoroughly investigated using real-world information in a large health care setting. During the early pandemic before the introduction of COVID-19 vaccination, advanced age, and medical comorbidities such as cardiovascular disease, diabetes, hypertension, and obesity (BMI greater than 30) were reported as poor prognostic factors.(Li et al., 2020; Singh et al., 2020) These studies focused on inpatient mortality and less on functional outcomes like discharge destination (home vs other than home) after hospitalization with COVID-19.

Due to the high prevalence of multi-organ involvement, impact on

* Corresponding authors at: Sunrise Health GME Consortium, Mt. View Medical Center, HCA Healthcare, 2880 N Tenaya Way, 2nd floor, Las Vegas, NV, United States.

E-mail address: sewlee2014@gmail.com (S.W. Lee).

https://doi.org/10.1016/j.pmedr.2023.102152
Received 24 August 2022; Received in revised form 16 December 2022; Accepted 14 February 2023
Available online 16 February 2023

the neurological system, and the associated debility seen in patients following intensive care unit level of stay, patients with COVID-19 often have significant need for rehabilitation during hospital stay and can require post-acute care after.(Johnson et al., 2021) Several studies evaluating disposition after hospitalization with COVID-19 were limited due to the logistical challenges in the early pandemic period and the small sample size. (Escalon and Herrera, 2020; Rodrigues et al., 2022).

This retrospective study intends to evaluate the association of COVID-19 vaccination, demographic, and medical comorbidities of patients with the outcome after hospital course among hospitalized COVID-19 patients in a large healthcare system.

1. Methods

Data without personal identifiers were collected from the electronic health record of the healthcare system comprised of more than 180 for-profit hospitals across 20 states in the United States. The inclusion criteria for this study were: symptomatic adult patients with an age greater than 18 years old, admitted with COVID-19 from January 1st, 2021 to December 31st, 2021. Patients without clear documentation of COVID-19 vaccination status during admission were removed. Patients who were discharged home from the emergency room were removed.

2. Variables

2.1. The primary variable of interest

Self-reported COVID-19 vaccination status was collected and the patient were considered vaccinated if they received a single dose or more from manufacturers (Stephenson et al., 2022).

2.2. Other variables

The demographic variables assessed included age, sex, race, ethnicity, medical coverage (healthcare insurance), length of hospital stay, and disposition destination.

Medical comorbidities were investigated using the Charlson Comorbidity Index, a validated, weighted scoring system, calculated based on 17 comorbid conditions, which was used to quantify the overall severity of illness and burden of disease in the patient population studies (Ofori-Asenso et al., 2018).

Initial vital signs included initial systolic, diastolic blood pressure, mean arterial pressure, heart rate, respiratory rate, temperature (highest during the first 24 h), and O2 saturation (lowest at the first 24 h). Initial and final laboratory findings during admission were obtained, including white blood cells with lymphocyte counts, d-dimer, and inflammatory markers (erythrocyte sedimentation rate [ESR], C-reactive protein [crp], ferritin and lactate dehydrogenase [LDH]).

COVID-19 treatments availing during the study period, including remdesivir and monoclonal antibodies were included for analysis.

3. Statistics

Demographic and clinical descriptive statistics were used utilizing the T-test, Kruskal-Wallis, Chi-square test, and Fisher exact test. Data tests were selected based upon the types of variables and normal distribution patterns.

A multivariate logistic regression analysis was used to evaluate relationships between independent variables (demographic and clinical variables) and the outcome variables of home discharge (vs no-home discharge) and inhospital mortality.

A generalized linear model was used to determine the association of length of stay and independent variables as described above.

A P-value of <0.05 was considered significant. Analyses were performed using SPSS, version 9.4 (SAS Institute, Inc., Cary, NC).

4. Results

There were 29,732 patients meeting both inclusion and exclusion criteria from January 1st, 2021 to December 31st, 2021 across the health care system. Seventy-three percent of patients (n = 21,525) patients were not vaccinated. The mean age of all the groups was 58.16 ± 17.39 (standard deviation) years, younger in the unvaccinated group compared to the vaccinated group (54.95 ± 16.75 vs 66.98 ± 16.01, P <.0001). There was a higher proportion of racial minority patients among the unvaccinated group (35.56 % vs 28.07 %, P <.0001). Hispanic and Latino ethnic group had a higher rate in the unvaccinated group (24.09 % vs 21.18 %, P <.0001). More medical comorbidities (higher CCI) were noted among the vaccinated group than among the unvaccinated group (4.74 ± 2.89 vs 2.70 ± 2.54, P <.0001). The average length of stay was 9.10 ± 10.63 days, significantly shorter in the vaccinated group compared to the unvaccinated group (9.49 ± 11.12 vs 8.04 ± 9.11 days, P <.0001). The vaccinated group had a lower percentage of patients requiring intensive care unit (ICU) care and also was associated with a shorter stay in the ICU. A higher proportion of patients received antiviral treatment in the unvaccinated group compared to the vaccinated group (31.62 % vs 24.32 %, P <.0001). Forty-three hundred twenty-eight patients expired during hospitalization (14.74 %) without significant difference between the group with or without vaccination. Table1 Fifty-eight percent (n = 17,109) of patients were discharged home. The group with the home discharge was younger (52.02 ± 15.99 vs 66.73 ± 15.55 years, P <.0001) and had shorter LOS (5.76 ± 6.10 vs 13.77 ± 13.48 days, P <.0001). Table 1.

COVID-19 vaccination was associated with decreased in-hospital mortality (odds ratio [OR] of 0.666, 95 % confidence interval [CI] of 0.580- 0.764), increased home discharge (OR of 1.168, CI 1.037–1.315), and decreased length of stay (-2.13 days, CI 2.73–1.55 days).

Each year in age was associated with decreased likelihood of home discharge by 5 % (OR 0.950, CI 0.946–0.953) and also associated with increased in-hospital mortality by 4 % (OR 1.04, CI 1.036–1.045). Non-Hispanic/Latino ethnicity was associated with decreased in-hospital mortality. (OR 0.691, CI 0.599–0.798), while minority race (Black and other race) was associated with increased odds of home discharge. Table 2.

Several medical comorbidities were associated with in-hospital mortality, home discharge, and length of stay. Cerebrovascular accident at admission was associated with increased in-hospital mortality (OR 3.005, CI 1.961–4.604), decreased home discharge (OR 0.415, CI 0.202–0.854), and increased length of stay by 8.37 days (CI 6.19–10.55 days).

5. Discussion

The current study demonstrates that receiving a dose of COVID-19 vaccine was associated with 33 % decreased mortality rate during hospitalization, correlated with 17 % higher likelihood of being discharged home (indicating higher functional level), and resulted in a decreased length of stay by 2.14 days among those patients hospitalized with COVID-19. This real-world data from the large health care system demonstrates how positive impacts of vaccination can extend beyond the decreased infection rates and overall disease severity reduction to include other hospital outcomes metrics observable in a subsequent wave (year 2) of the COVID-19 pandemic (Tenforde et al., 2021).

This study showed that breakthrough COVID-19 infection in the vaccinated group occurred in patients that were older and had more medical comorbidities compared to the patients admitted for COVID-19 infection among the unvaccinated group. The likelihood of patient home discharge decreasing with each year increase in age coupled with the decrease in inhospital mortality highlights the growing need for rehabilitation care to adequately address COVID-19 afflicted older patients. Early rehabilitation involvement to aid in improvement of overall health status, optimize function, improve self-care, assist patient in returning to

Table 1
Demographics and clinical characteristics between vaccinated and unvaccinated patients hospitalized with COVID-19.

	Total (n = 29,732)	Unvaccinated (n = 21,525, 73.28 %)	Vaccinated (n = 7847, 26.72 %)	P-Value
Age	58.16 ± 17.39	54.95 ± 16.75	66.98 ± 16.01	<0.0001
Sex – Male	15,063 (51.28 %)	11,026 (51.22 %)	4,037 (51.45 %)	0.736
Race				<0.0001
Black	5,011 (17.06 %)	3851 (17.89 %)	1160 (14.78 %)	
Other	4,846 (16.50 %)	3803 (17.67 %)	1043 (13.29 %)	
White	19.515 (66.44 %)	13,871 (64.44 %)	5644 (71.93 %)	
Ethnicity				<0.0001
Hispanic	6,847 (23.31 %)	5,185 (24.09 %)	1,662 (21.18 %)	
Non-Hispanic	22,525 (76.69 %)	16,340 (75.91 %)	6,185 (78.82 %)	
Insurance				<0.0001
Medicaid	3,811 (12.97)	3,182 (14.79)	628 (8.00)	
Medicare	12,284 (41.82)	7,227 (33.57)	5,057 (64.45)	
No Insurance	568 (1.93)	442 (2.05)	126 (1.61)	
Other	1,527 (5.20)	1,214 (5.64)	313 (3.99)	
Private	11,182 (38.07)	9,459 (43.94)	1,723 (21.96)	
Charlson medical comorbidity index	3.24 ± 2.79	2.70 ± 2.54	4.74 ± 2.89	<0.0001
Body mass index	31.48 ± 7.88	31.92 ± 7.92	30.27 ± 7.64	<0.0001
% of ICU stay	7,489 (25.50 %)	5,793 (26.91)	1,696 (21.61)	<0.0001
Days in intensive care unit	9.83 ± 11.59	10.59 ± 12.27	7.19 ± 8.35	<0.0001
Antiviral treatment	16,668 (56.75 %)	12,993 (60.36 %)	3,675 (46.83 %)	<0.0001
Remdesivir	16,280 (55.43 %)	12,751 (59.24 %)	3,529 (44.97 %)	
Monoclonal antibody	476 (1.62 %)	299 (1.39 %)	177 (2.26 %)	
Length of stay in days	9.10 ± 10.63	9.49 ± 11.12	8.04 ± 9.11	<0.0001
In hospital mortality	4328 (14.74 %)	3185 (14.80 %)	1143 (14.57 %)	0.622
Hospital acquired complications	1003 (3.41 %)	799 (3.53 %)	244 (3.11 %)	0.082
Discharge to home without service	17,109 (58.25 %)	13,369 (62.11 %)	3,740 (47.66 %)	<0.0001
Discharge other than home	12,263 (41.75 %)	3,740 (47.66 %)	4,107 (52.34 %)	
Vital signs on admission				
Systolic blood pressure	128.83 ± 15.89	127.84 ± 15.48	131.54 ± 16.67	<0.0001
Diastolic blood pressure	73.13 ± 7.85	73.47 ± 7.81	72.22 ± 7.87	<0.0001
Mean arterial pressure	91.62 ± 9.38	91.52 ± 9.32	91.89 ± 9.54	0.0007
Heart rate (highest)	102.75 ± 16.41	103.56 ± 16.05	100.51 ± 17.14	<0.0001
Respiratory rate (highest)	26.00 ± 8.18	26.36 ± 8.23	25.00 ± 7.75	<0.0001
SpO2 (lowest)	89.23 ± 4.20	88.93 ± 4.17	90.08 ± 4.14	<0.0001
Temperature (highest)	94.47 ± 16.38	94.60 ± 16.26	94.10 ± 16.70	<0.0001
Initial laboratory finding				
White blood cells ($x10^3/\mu L$), n = 28404	8.04 ± 4.22	7.81 ± 4.06	8.65 ± 4.57	<0.0001
Lymphocyte %, n = 30600	1.04 ± 0.59	1.02 ± 0.57	1.08 ± 0.67	0.0093
Platelets ($x10^3/\mu L$), n = 31498	1.06 ± 3.50	0.80 ± 2.54	1.95 ± 5.56	0.1016
C-Reactive Protein (mg/dL), n = 24080	9.73 ± 7.55	9.69 ± 7.41	9.84 ± 7.97	0.2401
D-dimer (mg/L fibrinogen-equivalent units), n = 12402	2285.57 ± 4589.24	2288.16 ± 4694.44	2277.01 ± 4222.98	<0.0001
Ferritin (ng/mL) n = 23884	909.97 ± 992.14	955.43 ± 1000.08	761.60 ± 950.93	<0.0001
Lactate dehydrogenase (international units/L), n = 16281	444.80 ± 259.25	466.98 ± 265.41	369.75 ± 221.39	<0.0001

baseline functional level, improve chance at home discharge, and reduce rate of re-hospitalization are all important objectives to address early and often during COVID related hospitalization. The rehabilitative needs of patients infected with COVID-19 do not end with hospital discharge. Early identification of patients who need substantial post-acute care can help the health care system better allocate the health care resources to address rehabilitative needs of recovering patients to maximize function and independence following acute hospitalization (Sheehy, 2020).

There is a disproportionate burden from COVID-19 infection among minority races and Hispanic/Latino populations in the US.(Stephenson et al., 2022) Similar to previous studies, the Hispanic/Latino population in this study continued to show increased odds of in-hospital mortality and continued overall lower rates of vaccination.(Agarwal et al., 2021; Wang et al., 2021). Additional patient data that expands the benefit from vaccination beyond mortality should be used to tailor ongoing patient education efforts to at risk groups to improve patient decision making, vaccination efforts, and reduce the disproportionate disease burden for these groups (Agarwal et al., 2021; Razai et al., 2021).

This study reaffirms the association of common medical comorbidities with overall outcomes after COVID-19 hospitalization. Similar to previous studies, hypertension, diabetes, chronic kidney disease, heart failure, chronic obstructive pulmonary disease, cerebrovascular accident (CVA), and liver disease were shown to be associated with in-hospital mortality, home discharge, and length of stay evaluated in this study (Zhou et al., 2020).

Retrospective study design with an inability to establish the causality and possibility of uncaptured confounding variables is one of the limitations. Also, the data collection from EHR data warehouse lacks the clinical details and underlying functional level of patients. There was a lack of information on residence type before admission that can affect the discharge pattern. Using administrative data such as billing codes cannot address the potential for unrecognized documentation errors. Exclusion of the large number of patients without clear vaccination status was a limitation although demographic characteristics of the excluded group were similar to those in this study.

The study population was limited to a private for-profit healthcare system and may have limited application to populations in other healthcare systems such as private, not-for-profit healthcare system, Veterans Affairs health care systems. or public health care system.

This study provides the positive impact of COVID vaccination on the length of stay and home disposition, in addition to decreased in-hospital mortality. COVID vaccination can be helpful beyond the mortality and the rate of hospitalization.

Table 2
Multivariate logistic regression for home discharge and in-hospital mortality and generalized linear model for hospital length of stay.

Effect	In hospital Mortality				Home discharge				Length of Stay			
	Odds ratio	95 % Confidence Limits		p-Value	Odds ratio	95 % Confidence Limits		p-Value	Estimate	95 % Confidence Limits		p-Value
COVID-19 Vaccination (compared to unvaccinated)	0.667	0.581	0.766	<0.0001	1.162	1.032	1.308	0.0132	−2.060	−2.650	−1.471	<0.0001
Age (per 1 year increase)	1.041	1.036	1.046	<0.0001	0.949	0.945	0.953	<0.0001				
Male sex (reference: Female sex)					1.214	1.098	1.342	0.0002				
Ethnicity Not Hispanic/Latino	0.702	0.609	0.811	<0.0001					−1.479	−2.088	−0.869	<0.0001
Race (reference: White)					1.199	1.045	1.375	0.0096	0.820	0.152	1.488	0.016
Black												
Other									1.490	0.807	2.174	<0.0001
Body mass index > 30	1.255	1.117	1.410	<0.0001								
Comorbidity (present vs not present)												
Hypertension	1.333	1.165	1.525	<0.0001	0.691	0.619	0.772	<0.0001	1.943	1.384	2.501	<0.0001
Diabetes	1.316	1.174	1.476	<0.0001	0.783	0.709	0.865	<0.0001	1.932	1.430	2.435	<0.0001
Chronic kidney disease	2.023	1.726	2.373	<0.0001	0.389	0.334	0.453	<0.0001	2.364	1.623	3.104	<0.0001
Coronary artery disease	1.214	1.050	1.405	0.0172								
Heart failure	1.270	1.073	1.503	0.0075	0.585	0.497	0.687	<0.0001	2.522	1.735	3.310	<0.0001
Asthma	1.335	1.085	1.642	0.0056	0.832	0.697	0.992	0.0404				
COPD	1.455	1.244	1.703	<0.0001	0.705	0.608	0.817	<0.0001	1.580	0.841	2.318	<0.0001
Cerebrovascular accident	3.035	1.975	4.662	<0.0001	0.157	0.087	0.283	<0.0001	8.436	6.273	10.600	<0.0001
Systemic lupus erythematous and rheumatoid arthritis	1.526	1.094	2.130	0.0142	0.637	0.467	0.868	0.0043				
Liver disease	3.061	2.187	4.283	<0.0001	0.356	0.248	0.510	<0.0001	5.800	4.105	7.495	<0.0001
Initial vital sign and laboratory results												
Heart rate (per 1 increase)	1.006	1.003	1.010	0.0005	0.993	0.990	0.996	<0.0001				
Respiratory rate (per 1 increase)	1.035	1.028	1.042	<0.0001	0.963	0.957	0.969	<0.0001	0.158	0.127	0.189	<0.0001
Spo2 (per 1 % increase)	0.903	0.889	0.917	<0.0001	1.067	1.052	1.081	<0.0001	−0.307	−0.372	−0.241	<0.0001
Mean arterial pressure (per 1 unit increase)					1.011	1.005	1.016	0.0001				
White blood cell count									0.198	0.134	0.262	<0.0001
Absolute lymphocyte count	0.700	0.621	0.790	<0.0001	1.371	1.243	1.512	<0.0001	−1.878	−2.347	−1.410	<0.0001
C-reactive protein	1.020	1.013	1.028	<0.0001	0.992	0.985	0.998	0.0147	0.062	0.029	0.095	0.000
D-dimer (per 1000 increase)					0.978	0.967	0.988	<0.0001	0.061	0.010	0.113	0.020
Ferritin (per 1000 increase)	1.243	1.179	1.309	<0.0001	0.826	0.785	0.870	<0.0001				

6. Disclaimer

This research was supported (in whole or in part) by HCA and/or an HCA affiliated entity. The views expressed in this publication represent those of the author(s) and do not necessarily represent the official views of HCA or any of its affiliated entities.

CRediT authorship contribution statement

Se Won Lee: Conceptualization, Methodology, Project administration, Investigation. **Adrian Davoodian:** Project administration, Writing - original draft, Writing - review & editing. **Napatkamon Ayutyanont:** Methodology, Project administration, Data curation, Formal analysis, Writing - review & editing. **Bryan Werner:** Conceptualization, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

References

Agarwal, R., Dugas, M., Ramaprasad, J., Luo, J., Li, G., Gao, G., 2021. Socioeconomic privilege and political ideology are associated with racial disparity in COVID-19 vaccination. PNAS 118 (33).

Escalon, M.X., Herrera, J., 2020. Adapting to the coronavirus disease 2019 pandemic in New York City. Am. J. Phys. Med. Rehabil. 99 (6), 453–458.

Johnson, J.K., Lapin, B., Green, K., Stilphen, M., 2021. Frequency of physical therapist intervention is associated with mobility status and disposition at hospital discharge for patients with COVID-19. Phys. Ther. 101.

Kirson, N., Swallow, E., Lu, J., Foroughi, C., Bookhart, B., DeMartino, J.K., Maynard, J., Shivdasani, Y., Eid, D., Lefebvre, P., 2022. Increasing COVID-19 vaccination in the united states: projected impact on cases, hospitalizations, and deaths by age and racial group. Public Health 210, 99–106.

Lam, C.N., Kaplan, C., Saluja, S., 2021. Relationship between mask wearing, testing, and vaccine willingness among Los Angeles County adults during the peak of the COVID-19 pandemic. Transl. Behav. Med. 12, 480–545.

Li, B., Yang, J., Zhao, F., Zhi, L., Wang, X., Liu, L., Bi, Z., Zhao, Y., 2020. Prevalence and impact of cardiovascular metabolic diseases on COVID-19 in China. Clin. Res. Cardiol. 109, 531–558.

Ofori-Asenso, R., Zomer, E., Chin, K.L., Si, S., Markey, P., Tacey, M., Curtis, A.J., Zoungas, S., Liew, D., 2018. Effect of comorbidity assessed by the charlson comorbidity index on the length of stay, costs and mortality among older adults hospitalised for acute stroke. Int. J. Environ. Res. Public Health 15, 2532.

Proportions, V., 2022. COVID Data Tracker.

Razai, M.S., Chaudhry, U.A., Doerholt, K., Bauld, L., Majeed, A., 2021. Covid-19 vaccination hesitancy. BMJ 373.

Rodrigues, M., Costa, A.J., Santos, R., Diogo, P., Gonçalves, E., Barroso, D., Almeida, M. P., Vaz, I.M., Lima, A., 2022. Inpatient rehabilitation can improve functional outcomes of post-intensive care unit COVID-19 patients-a prospective study. Disabil. Rehabil. 1–11.

Sadoff, J., Gray, G., Vandebosch, A., Cárdenas, V., Shukarev, G., Grinsztejn, B., Goepfert, P.A., Truyers, C., Van Dromme, I., et al., 2022. Final analysis of efficacy and safety of single-dose Ad26. COV2. S. New England Journal of Medicine 386, 847–860.

Sen, P., Yamana, T.K., Kandula, S., Galanti, M., Shaman, J., 2021. Burden and characteristics of COVID-19 in the United States during 2020. Nature 598, 338–341.

Sheehy, L.M., 2020. Considerations for postacute rehabilitation for survivors of COVID-19. JMIR Public Health Surveill. 6, e19462.

Singh, A.K., Gupta, R., Ghosh, A., Misra, A., 2020. Diabetes in COVID-19: Prevalence, pathophysiology, prognosis and practical considerations. Diabetes Metab. Syndr. 14, 303–310.

Sparks, G., Lopes, L., Montero, A., Hamel, L., M, B., 2022. KFF COVID-19 Vaccine Monitor: April 2022, pp. https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-april-2022/view/footnotes/.

Stephenson, M., Olson, S.M., Self, W.H., Ginde, A.A., Mohr, N.M., Gaglani, M., Shapiro, N.I., Gibbs, K.W., Hager, D.N., et al., 2022. Ascertainment of vaccination status by self-report versus source documentation: impact on measuring COVID-19 vaccine effectiveness. Influenza Other Respir. Viruses 16, 1101–1111.

Tenforde, M.W., Self, W.H., Adams, K., Gaglani, M., Ginde, A.A., McNeal, T., Ghamande, S., Douin, D.J., Talbot, H.K., et al., 2021. Association between mRNA vaccination and COVID-19 hospitalization and disease severity. J. Am. Med. Assoc. 326, 2043–2054.

Wang, Y., Ristea, A., Amiri, M., Dooley, D., Gibbons, S., Grabowski, H., Hargraves, J.L., Kovacevic, N., Roman, A., et al., 2021. Vaccination intentions generate racial disparities in the societal persistence of COVID-19. Sci. Rep. 11, 1–13.

Zhou, F., Yu, T., Du, R., Fan, G., Liu, Y., Liu, Z., Xiang, J., Wang, Y., Song, B., et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet.