Acıbadem Univ. Sağlık Bilim. Derg. 2023; 14 (4): 724-730
https://doi.org/10.31067/acusaglik.1259681

ORIGINAL ARTICLE / ARAŞTIRMA YAZISI

Healthcare Management / Sağlık Yönetimi

Evaluation of Vaccination and Polymerase Chain Reaction Test Positivity of Hospital Personnel During the COVID-19 Pandemic

Yasemin Aslan[1], Ekrem Sevim[1], Sinem Güler[2]

[1]Bandırma Onyedi Eylül University, Faculty of Health Sciences, Department of Health Management, Balıkesir, Turkey

[2]Occupational Health and Safety, BAU Medical Park Goztepe Hospital, Istanbul, Turkey

ABSTRACT

Objective: This study aimed to evaluate the vaccination and polymerase chain reaction (PCR) test positivity of hospital personnel during the COVID-19 pandemic.

Methods: The research is a retrospective cross-sectional study and was conducted in a university hospital in Istanbul between January 01, 2021, and December 31, 2021. The data of 572 personnel, who did not experience admission to employment-quit job mobility, were evaluated in the study. Descriptive statistics and Chi-square test were used to analyze the dataset.

Results: According to the findings, it was seen that 95% of the participants had at least one dose of vaccination, and the participants aged 51 and over together with the physicians had the highest vaccination rate. It was conducted that 9% of the participants had a chronic disease, and 3% of the participants were hospitalized due to COVID-19. It was determined that the pre-vaccination PCR positivity rate of hospital personnel was 19%, and the post-vaccination PCR positivity rate was lower than those who did not get vaccinated. In the study, a statistically significant difference was found between vaccination status of the participants and post-vaccine PCR positivity ($p<0.05$).

Conclusion: It is important to make arrangements for the vaccination of hospital personnel with the high-risk group in terms of transmission during the pandemic.

Keywords: COVID-19, Hospital Personnel, PCR, Vaccination

Yasemin ASLAN
Ekrem SEVİM
Sinem GÜLER

COVID-19 Pandemisi Sürecinde Hastane Çalışanlarının Aşılanma ve Polimeraz Zincir Reaksiyonu Testi Pozitiflik Durumunun Değerlendirilmesi

ÖZET

Amaç: Bu çalışmanın amacı COVID-19 pandemisi sürecinde hastane çalışanlarının aşılanma ve polimeraz zincir reaksiyonu (PCR) testi pozitiflik durumlarının değerlendirilmesidir.

Yöntem: Retrospektif türde kesitsel olarak tasarlanan çalışma İstanbul'da yer alan bir üniversite hastanesinde 01.01.2021-31.12.2021 tarihleri arasında yapılmıştır. Çalışmada işe giriş-çıkış hareketliliği yaşamamış 572 personelin verileri değerlendirilmiştir. Verilerin analizinde tanımlayıcı istatistiklerden ve Ki-kare testinden yararlanılmıştır.

Bulgular: Çalışma sonucunda elde edilen bulgulara göre, katılımcıların %95'inin en az bir doz aşı yaptırdığı, 51 yaş ve üzeri katılımcılar ile hekimlerin en yüksek aşılanma oranına sahip olduğu görülmüştür. Katılımcıların %9'unun kronik hastalık öyküsü olduğu, %3'ünün COVID-19 nedeniyle hastanede yatarak tedavi gördüğü tespit edilmiştir. Araştırmada hastane çalışanlarının aşılanma öncesi PCR pozitiflik oranının %19 olduğu, COVID-19 aşısı yaptıran çalışanların aşılama sonrası PCR pozitiflik oranının, aşı yaptırmayan çalışanlara oranla daha düşük olduğu tespit edilmiştir. Çalışmada aşı olma durumu ile aşı sonrası PCR pozitifliği arasında istatistiksel olarak anlamlı bir fark saptanmıştır ($p<0,05$).

Sonuç: Pandemi sürecinde bulaşma açısından yüksek risk grubunda yer alan hastane personelinin aşılanmasına yönelik düzenlemelerin yapılması önemlidir.

Anahtar Kelimeler: COVID-19, Hastane çalışanları, PCR, Aşılanma

Correspondence: Yasemin Aslan
Bandırma Onyedi Eylül University, Faculty of Health Sciences, Department of Health Management, Balıkesir, Turkey
Phone: +905359601240
E-mail: yaseminaslan@bandirma.edu.tr

Received: 03 March 2023
Accepted: 19 June 2023

The coronavirus disease, which emerged in China in December 2019, has caused severe and fatal respiratory symptoms in humans. Many countries announced the number of cases and declared a health emergency soon after it was seen in China. The World Health Organization (WHO) has declared COVID-19 a global pandemic on March 11, 2020. The Ministry of Health reported the first COVID-19 case in Turkey on the same day that the pandemic was declared.

The pandemic has caused great pressure on the health systems of the countries. Healthcare personnel made great efforts in terms of the sustainability of the system, and they have played an important role in the fight against to the virus during pandemic. They are the most valuable resource in the global fight against COVID-19, and ensuring their safety is one of the top priorities (1). Especially hospital personnel who have close contact with patients infected by the COVID-19 virus have been evaluated in the high-risk group (2). Therefore, it has been stated that protecting the personnel is crucial for patient treatment and the prevention of transmission to other patients (1,3,4). According to a study conducted in Korea, healthcare personnel have a high risk of contracting the COVID-19 pandemic, and governments should make regulations to protect them (5).

Vaccination is one of the most effective ways to protect healthcare personnel from COVID-19 infection. Vaccines are the most powerful and cost-effective way to prevent infectious diseases worldwide. Evidence- based studies show that vaccines can reduce COVID-19 infection (6,7). Nguyen et al. found that vaccines reduce COVID-19 infection by 70-90% and protect healthcare personnel against serious infections (8). Centers for Disease Control and Prevention (CDC) stated that COVID-19 vaccines protect people against infection, symptomatic illness, hospitalization, and death (9). According to another study conducted in China, it is critical to develop proper vaccine strategies and immunization programs in order to respond to the COVID-19 pandemic (10). Therefore, healthcare personnel have been evaluated as the priority group in terms of access to vaccines in many countries (11). WHO and the Ministry of Health have also identified healthcare personnel as the priority group for vaccination against COVID-19 (12,13). In addition, vaccination is mandatory for healthcare personnel in some countries (14). At this point, management approaches to immunization are becoming increasingly important in the fight against the COVID-19 pandemic.

The success of vaccination programs depend on several requirements such as the understanding of leadership that responds quickly in the effective fight against the pandemic, the use of appropriate screening methods, effective treatment, evidence-based education programs and protocols, and also surveillance studies (4,13). When these requirements are not adequately satisfied, healthcare personnel suffers a variety of issues, such as infection risk, fear of death, anxiety, stress, depression, and stigmatization (15). In addition, research shows that previous COVID-19 infections protect individuals against new infections, and this protection lasts 4-6 months for the majority of healthcare personnel (16,17). Therefore, polymerase chain reaction (PCR) tests are important for the effective use of vaccines and the early detection of asymptomatic COVID-19 cases. This study aimed to evaluate the vaccination and PCR test positivity of hospital personnel during the COVID-19 pandemic. The study's contribution to the literature is summarized below:

- To be informed about the state of being affected by COVID-19, the number of vaccine doses, PCR positivity according to the occupational group, and the immunization rates of hospital personnel in a university hospital during the COVID-19 pandemic
- To examine the relationship between vaccination and PCR positivity
- Contributing to the determination of institutional policies for the protection of hospital personnel during the pandemic.

MATERIAL AND METHODS

The retrospective cross-sectional study was conducted in a university hospital in Istanbul. Institutional permission was obtained for the research.

Samples

In the study, the data of 572 personnel who worked in the institution between January 01, 2021, and December 31, 2021, and who did not experience admission to employment-quit job mobility were evaluated. In the study, sample selection was not made and the entire population was taken into consideration.

Measures

The records of the occupational health and safety unit were used as a data collection tool. In the study, participants' age, gender, profession, chronic disease history,

hospitalization due to COVID-19, being vaccinated against COVID-19, and PCR test positivity were evaluated.

Data Analysis

The data were analyzed using IBM SPSS (Version 23.0). Descriptive statistics and chi-square test were used in the data analysis.

RESULTS

Descriptive characteristics of the participants are shown in Table 1. Accordingly, 65% of the participants were women, 32.3% were in the 20-29 age group, 25.3% were support services personnel, and 95.1% had at least one dose of COVID-19 vaccine. In addition, it was seen that 3.3% of the participants were hospitalized due to COVID-19, 19.1% had a positive PCR test before vaccination, and 14% had a positive post-vaccination PCR test.

The relationship between the third and fourth dose of vaccination of the participants by occupation is shown in Table 2. A statistically significant difference was found between getting the third and fourth dose of the vaccine according to the occupation of the participants ($p<0.05$). In the further analysis, it was determined that for the third and fourth dose, the difference was between physicians and all occupation categories.

The relationship between the third and fourth dose of the vaccination of the participants by age is shown in Table 3. A statistically significant difference was found between getting the third and fourth dose of the vaccine according to the age groups of the participants ($p<0.05$). In the further analysis, it was determined that the difference for the third dose was between the 20-29 age group and the 40-49 and 50 and over age group. For the fourth dose, it was determined that the difference was between the 20-29 age group and the other age groups, and the 50 and over age group and the 30-39, 40-49 age groups.

The relationship between pre-vaccine PCR positivity and post-vaccine PCR positivity with hospitalization is shown in Table 4. A statistically significant difference was found between the pre- and post-vaccine PCR positivity ($p<0.001$). Post-vaccination PCR positivity rate was found to be lower in vaccinated group compared to non-vaccinated ones. According to the Fisher's Exact Test results, which were performed to evaluate the relationship between pre-vaccine PCR positivity and hospitalization of the participants in Table 4, there is a statistically significant difference between pre-vaccine PCR positivity and hospitalization ($p<0.001$).

Table 1. Descriptive Characteristics of the Participants (N:572)

Variables		n	%
Gender			
Male		200	35
Female		372	65
Age			
20-29		185	32.3
30-39		163	28.5
40-49		146	25.5
50 and over		78	13.6
Profession			
Physician		86	15.0
Nurse		123	21.5
Technician		51	8.9
Administrative personnel		138	24.1
Support services		145	25.3
Other		29	5.1
State of being vaccinated			
Yes		544	95.1
No		28	4.9
Hospitalization status			
Yes		19	3.3
No		553	96.7
Pre-vaccine PCR positivity status			
Yes		109	19.1
No		463	80.9
Post-vaccine PCR positivity status			
Yes		80	14.0
No		492	86.0
State of being vaccinated			
1st Dose	**Yes**	544	95.1
	No	28	4.9
2nd Dose	**Yes**	533	93.2
	No	39	6.8
3rd Dose	**Yes**	389	68.0
	No	183	32.0
4th Dose	**Yes**	175	30.6
	No	397	69.4
5th Dose	**Yes**	3	0.5
	No	569	99.5
Total		**572**	**100**

Table 2. The Relationship between the Third and Fourth Vaccination Dose of the Participants by Professions

	Yes		No		X^2	SD	p
Third dose vaccination status							
	n	%	n	%			
Physician	82	21.1	4	2.2	48.790	5	.000
Nurse	75	19.3	48	26.2			
Technician	33	8.5	18	9.8			
Administrative personnel	92	23.7	46	25.1			
Support services	81	20.8	64	35			
Other	26	6.7	3	1.6			
Total	**389**	**100**	**183**	**100**			
Fourth dose vaccination status							
Physician	68	38.9	18	4.5	124.927	5	.000
Nurse	26	14.9	97	24.4			
Technician	10	5.7	41	10.3			
Administrative personnel	41	23.4	97	24.4			
Support services	19	10.9	126	31.7			
Other	11	6.3	18	4.5			
Total	**175**	**100**	**397**	**100**			

Table 3. The Relationship between the Third and Fourth Vaccination Dose of the Participants by Age

	Yes		No		X^2	SD	p
Third dose vaccination status							
	n	%	n	%			
20-29	110	28.3	75	41	20.053	3	.000
30-39	108	27.8	55	30.1			
40-49	103	26.5	43	23.5			
50 and over	68	17.5	10	5.5			
Total	389	100	183	100			
Fourth dose vaccination status							
20-29	31	17.7	154	38.8	42.668	3	.000
30-39	46	26.3	117	29.5			
40-49	55	31.4	91	22.9			
50 and over	43	24.6	35	8.8			
Total	175	100	397	100			

Table 4. The relationship between Pre-vaccine PCR Positivity and Post-vaccine PCR Positivity and Hospitalization

		Yes		No		X^2	SD	p
Post-vaccine PCR positivity								
		n	%	n	%			
Pre-vaccine PCR positivity	**Yes**	3	2.8	106	97.2	14.126	1	.000
	No	77	16.6	386	83.4			
	Total	80	14	492	86			
Hospitalization status								
		Yes		**No**		X^2	SD	p
		n	%	n	%			
Pre-vaccine PCR positivity	**Yes**	13	11.9	96	88.1	31.049	1	.000
	No	6	1.3	457	98.7			
	Total	19	3.3	553	96.7			

DISCUSSION AND CONCLUSION

In the study, it was found that 95% of the participants had at least one dose of COVID-19 vaccine and the highest vaccination rate was in the 50 years and older group. The rate of vaccination increases with age. Tyagi et al. and Peirolo et al. found the vaccination rate of healthcare personnel to be 91.9% and 88%, respectively, consistent with our findings (18,19). According to a comprehensive study that included 3,357,348 healthcare personnel from 2,086 hospitals in the United States, 70% of the participants were vaccinated, and concluded that more efforts were needed to boost the immunization rate (20). Another study conducted in Colombia found that full vaccination against COVID-19 is effective in preventing COVID-19 hospitalization and deaths in adults aged 60 and over, stated that vaccines should be evaluated in the priority group because their effectiveness decreases with the age, and that a booster dose can be recommended (21). In addition, CDC noted that adults over the age of 65 who received the vaccine had a 94% reduction in the risk of COVID-19-related hospitalization (22). The highest rate of vaccination in the older age group can be explained by the increased risk of contracting the disease with the age.

In the study, physicians were found to be the most vaccinated group, with more than 90% of individuals in other occupations having received at least one dose of immunization. Lee et al. found that vaccination coverage was the highest among physicians similarly (75.1%) (23). Many specialist and professional organizations have recommended the COVID-19 vaccination that protects patients and healthcare personnel from COVID-19 infection (24). Physicians' high immunization rate can be explained by their strong conviction in the efficacy of COVID-19 vaccines.

It was determined that 9% of the hospital personnel had a history of chronic disease and all of these individuals had at least one dose of the COVID-19 vaccine. Peirolo et al. found the vaccination rate of healthcare personnel with chronic diseases as 89% (19), consistent with our findings. These outcomes suggest that healthcare personnel with chronic diseases are more sensitive to vaccination.

According to the study, hospitalization symptoms occurred in 3.3% of the participants, and there was a statistically significant difference between pre-vaccination PCR positivity and hospitalization. In general, participants with high pre-vaccine PCR positivity had a higher hospitalization rate. Additionally, it was found that no personnel died during the study period. Toniasso et al. reported a 4.9% hospitalization rate in healthcare personnel diagnosed with COVID-19, and no one who tested positive died (6). However, pre-vaccination PCR tests on six hospitalized and treated participants were negative. It is thought that viral exposure and individual characteristics may have an impact on this result. Additional studies should be conducted to determine the association between immunizations, PCR positivity, and hospitalization.

Study results have showed that participants with pre-vaccine PCR positivity had lower post-vaccine PCR positivity compared to those who did not. Studies conducted in Denmark and Qatar have found that the presence of a previous diagnosis of COVID-19 infection provides up to 78.8% and 95% protection against a new infection, respectively (25,26). In a multicenter, prospective cohort study of hospital personnel in the United Kingdom, it was found that the presence of a previous coronavirus infection was associated with an 83% lower risk of infection, consistent with our study (27). Another study carried on 12,541 healthcare personnels in the UK showed that a previous COVID-19 infection provided 89% protection for at least 6 months (17). However, the CDC has stated that some people who are vaccinated are at risk of contracting COVID-19 and that no vaccine is 100% effective (9). A different study conducted in Brazil showed PCR positivity in 35.4% of vaccinated healthcare personnel with COVID-19 symptoms (6). Furthermore, Tyagi et al. found that the rate of PCR positive after the vaccination, considered to be related to the vaccine, was 16.9% (18). It might be influenced by the type of vaccine, the timing of vaccination, the age of the personnel, the presence of chronic diseases, the viral load to which the personnel are exposed, the immune system, and factors like prior COVID-19 infection. Therefore, the protective effect of PCR positivity should be taken into account in the determination of vaccination policies for hospital personnel.

Study results have showed that 4.9% of the personnel were not vaccinated against COVID-19. In a study carried out in India, 8.1% of the personnel working in hospitals were found to be COVID-19 unvaccinated (18). Another study, involving 776 healthcare personnels who preferred to participate in the study at a university hospital in Geneva, found that 11.9% of participants were not vaccinated (24). One of the factors affecting vaccination in healthcare personnel may be vaccination hesitancy. Studies show that the prevalence of COVID-19 vaccine hesitancy in healthcare personnel worldwide ranges from 4.3% to 72% (the average rate of individuals who are hesitant to 22.51%) (28).

Studies conducted to evaluate the factors that cause vaccine indecision among healthcare personnel show that there are concerns about the efficacy of the COVID-19 vaccine, its side effects, the speed of vaccine development, and the lack of the Food and Drug Administration approval (29). The CDC noted that the risk of contracting COVID-19 increases with age, especially older adults are more likely to be affected by COVID-19. It is important for health policymakers and hospital administrators to create strategies to improve the working conditions of healthcare personnel and increase their commitment to universal precautions during the pandemic (30).

Healthcare personnels are critical, as they are the key target group for immunization programs and have a huge impact on the vaccination preferences of the general population. WHO, CDC, and Ministry of Health evaluated hospital personnel in the priority group in the vaccination list against COVID-19. According to the study, hospital personnel generally had high COVID-19 immunization rates for all occupations. A high incidence of vaccination in all occupations in a university hospital in Turkey was considered a positive outcome at a time when there were hesitations about vaccination among individuals and healthcare professionals around the world. Considering that the PCR test positivity rate among vaccinated personnel is lower than in those who were not vaccinated, this is important in emphasizing the significance of vaccination. However, the effect of previous coronavirus infections on immunization should not be ignored. Past infections provide a high level of protection for about 6 months (26). This is important in terms of the effectiveness of institutional-level vaccination programs and the planning of equal, equitable, and fair access to the vaccine. Because the countries' economic resources are limited, and the number of personnel who require immunization during the pandemic is high. It may be helpful for the infection control committees of hospitals to consider that hospital personnel who are PCR-positive before vaccination have immunity for a certain period of time. In this context, PCR positivity should be taken into account when planning the vaccination program in hospitals.

The personnels' attitude toward the vaccine becomes crucial when taking into account how immunizations affect PCR positives. It may be beneficial to provide training to health institution personnel on the importance of vaccination. To protect hospital personnel, especially those who are in the high-risk group in terms of disease transmission, against COVID-19 infection during the pandemic, policymakers and health institution managers at the country level should make regulations to increase vaccination rates and monitor healthcare personnel. This is important for the protection of healthcare personnel and the public. Since vaccines are known to be the strongest and most cost-effective way to protect against infectious diseases worldwide, it can be stated that vaccination studies are also important in terms of the management of similar situations that may emerge in the future. In addition, evidence-based guidelines should be followed for planning the vaccination of PCR-positive hospital personnel.

Limitations

The research is limited to the personnel who worked in a university hospital between January 01, 2021, and December 31, 2021, and did not experience admission to employment-quit job mobility. Another limitation of the study is the situation of personnel who without symptoms, do not have a PCR test, or are not required to be tested by the physician.

DECLARATIONS

Funding

No financial support was received for the study.

Conflicts of Interest

There are no potential conflict of interest was reported by the authors.

Ethics Approval

Ethical approval that the study was ethically appropriate was obtained with decision number 2022-3 on March 11, 2022 from the Bandırma Onyedi Eylül University Health Sciences Non-Interventional Research Ethics Committee. To conduct the present study, the ethical principles for medical research on human subjects established by the Declaration of Helsinki were followed.

Availability of Data and Material

The dataset of this study are available from the corresponding author on reasonable request.

Authors Contributions

Conceived and designed the analysis YA; collected the data YA, SG; contributed data or analysis tools YA, ES, SG; performed the analysis YA, ES; wrote the paper YA, ES; critical review YA, ES, SG.

REFERENCES

1. Lancet T. COVID-19: Protecting health-care workers. The Lancet. 2020;395(10228):P922. DOI:10.1016/S0140-6736(20)30644-9
2. Nguyen LH, Drew DA, Graham MS, et al. Risk of COVID-19 among front-line health-care workers and the general community: A prospective cohort study. Lancet Public Health. 2020;5:e475-83. DOI:10.1016/S2468-2667(20)30164-X.
3. Tan Z, Wen D, Khoo DWS, et al. (2020). Protecting health care workers in the front line: Innovation in COVID-19 pandemic. J Glob Health. 2020;10(1):010357. DOI:10.7189/jogh.10.010357.
4. Wang J, Zhou M and Liu F. Reasons for healthcare workers becoming infected with Novel Coronavirus Disease 2019 (COVID-19) in China. J Hosp Infect. 2020;105(1):100-1. DOI:10.1016/j.jhin.2020.03.002
5. Lee J, and Kim M. Estimation of the number of working population at high-risk of COVID-19 infection in Korea. Epidemiol Health. 2020;42:e2020051. DOI:10.4178/epih.e2020051
6. Toniasso S, Fernandes FS, Joveleviths D, et al. Reduction in COVID-19 prevalence in healthcare workers in a university hospital in Southern Brazil after the start of vaccination. Int J Infect Dis. 2021;109:283-5. DOI:10.1016/j.ijid.2021.07.025
7. Daniel W, Nivet M, Warner J, et al. Early evidence of the effect of SARSCoV-2 vaccine at one medical center. N Engl J Med. 2021;384:1962-3 DOI:10.1056/NEJMc2102153
8. Nguyen T, Adnan M, Nguyan BP, et al. (2021). COVID-19 vaccine strategies for Aotearoa New Zealand: A mathematical modelling study. The Lancet Regional Health-Western Pacific. 2021;15:100256. DOI:https://doi.org/10.1016/j.lanwpc.2021.100256
9. Centers for Diseases Control and Prevention (CDC). (2022, June 29). COVID-19 vaccines are effective. https://www.cdc.gov/coronavirus/2019-ncov/vaccines/effectiveness/index.html.
10. Wang M-W, Wen W, Wang N, et al. COVID-19 vaccination acceptance among healthcare workers and non-healthcare workers in China: A Survey. Front Public Health. 2021;9:709056. DOI:10.3389/fpubh.2021.709056
11. Amit S, Beni SA, Biber A, et al. (2021). Postvaccination COVID-19 among healthcare workers. Israel. Emerging Infectious Diseases. 2021;27(4):1220-2. DOI:10.3201/eid2704.210016
12. WHO. Implementation guide for vaccination of health workers. Geneva: World Health Organization; Licence: CC BY-NC-SA 3.0 IGO; 2022.
13. Ministry of Health. (2023, March 3). Group ranking to be vaccinated. https://covid19asi.saglik.gov.tr/TR-77707/asi-uygulanacak-grup-siralamasi.html.
14. Paterlini M. COVID-19: Italy makes vaccination mandatory for healthcare workers. BMJ. 2021;373:n905. DOI:10.1136/bmj.n905
15. Amnesty International. Exposed, silenced, attacked: failures to protect health and essential workers during the COVID-19 pandemic. London, UK:Amnesty International; 2020.
16. Narrainen F, Shakeshaft M, Asad H, et al. (2021). The protective effect of previous COVID-19 infection in a high-prevalence hospital setting. Clin Med (Lond). 2021;21(5):e470-e474. DOI:10.7861/clinmed.
17. Lumley SF, O'Donnell D, Stoesser NE, et al. Antibody Status and Incidence of SARS-CoV-2 Infection in Health Care Workers. NEJM. 2021;384(6):533-40. DOI:10.1056/NEJMoa2034545.
18. Tyagi K, Ghosh A, Nair D, et al. Breakthrough COVID19 ınfections after vaccinations in healthcare and other workers in a chronic care medical facility in New Delhi, India. Diabetes Metab Syndr. 2021;15(3):1007-8. DOI:10.1016/j.dsx.2021.05.001
19. Peirolo A, Posfay-Barbe KM, Rohner D, et al. (2022). Acceptability of COVID-19 vaccine among hospital employees in the department of paediatrics, gynaecology and obstetrics in the university hospitals of Geneva, Switzerland. Front Public Health. 2022;9:781562. DOI:10.3389/fpubh.2021.781562
20. Reses HE, Jones ES, Richardson DB, et al. COVID-19 vaccination coverage among hospital-based healthcare personnel reported through the department of health and human services unified hospital data surveillance system, United States, January 20, 2021-September 15, 2021. Am J Infect Control. 2021;49(12):1554-7. DOI:10.1016/j.ajic.2021.10.008
21. Arregocés-Castillo L, Fernández-Niño J, Rojas-Botero M, et al. Effectiveness of COVID-19 vaccines in older adults in Colombia: A retrospective, population-based study of the ESPERANZA cohort. The Lancet Healthy Longev. 2022;3:e242-52. DOI:10.1016/S2666-7568(22)00035-6
22. Centers for Diseases Control and Prevention (CDC). Effectiveness of COVID-19 vaccines in preventing hospitalization among adults aged ≥65 years - COVID-NET, 13 States, February-April 2021. Morb Mortal Wkly Rep. 2021;70(32):1088-93. DOI:10.15585/mmwr.mm7032e3
23. Lee JT, Althomsons SP, Wu H, et al. Disparities in COVID-19 Vaccination Coverage Among Health Care Personnel Working in Long-Term Care Facilities, by Job Category, National Healthcare Safety Network-United States, March 2021. MMWR Morb Mortal Wkly Rep. 2021;70:1036-9. DOI:10.15585/mmwr.mm7030a2
24. Association of American Medical Colleges. (2021, July 26). Major health care professional organizations call for COVID-19 vaccine mandates for all health workers. https://www.aamc.org/news-insights/press-releases/major-health-care-professional-organizations-call-covid-19-vaccine-mandates-all-health-workers.
25. Hansen CH, Michlmayr D, Gubbels SM, et al. (2021). Assessment of protection against reinfection with SARS-CoV-2 among 4 million PCR-tested individuals in Denmark in 2020: A population-level observational study. Lancet. 2021;397(10280):P1204-12. DOI:10.1016/S0140-6736(21)00575-4
26. Abu-Raddad LJ, Chemaitelly H, Coyle P, et al. SARS-CoV-2 antibody-positivity protects against reinfection for at least seven months with 95% efficacy. EClinicalMedicine. 2021;35:100861. DOI:10.1016/j.eclinm.2021
27. Hall VJ, Foulkes S, Charlett A, et al. (2021). SARS-CoV-2 infection rates of antibody-positive compared with antibody-negative health-care workers in England: A large, multicentre, prospective cohort study (SIREN). Lancet. 2021;397(10283):1459-69. DOI:10.1016/S0140-6736(21)00675-9
28. Biswas N, Mustapha T, Khubchandani J, et al. The nature and extent of COVID-19 vaccination hesitancy in healthcare workers. J Community Health. 2021;46(6):1244-51. DOI:10.1007/s10900-021-00984-3
29. Shekhar R, Sheikh AB, Upadhyay S, et al. COVID-19 vaccine acceptance among health care workers in the United States. Vaccines (Basel). 2021;9(2):119-34. DOI:10.3390/vaccines9020119
30. Bekele T, Gebremariam A, Kaso M, et al. (2015). Factors associated with occupational needle stick and sharps injuries among hospital healthcare workers in Bale Zone, Southeast Ethiopia. PLoS ONE. 2015;10(10):e0140382. DOI:10.1371/journal.pone.0140382