

INCIDENCE AND RISK FACTORS OF COVID-19 INFECTION IN HEALTHCARE WORKERS AT A TERTIARY REFERRAL CENTRE: FROM THE FIRST TO THE SIXTH WAVE OF THE PANDEMIC

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SUMMARY

Objectives: The aim of the study was to determine the incidence of COVID-19 infection among healthcare workers (HCWs) at Reina Sofía University Hospital (RSUH) in Córdoba, Spain, from the first to the sixth wave of the pandemic. Additionally, we analysed the characteristics of infections across different age groups, genders, professional categories, hospital services, and COVID-19 vaccination status.

Methods: An observational, longitudinal, analytical, and retrospective study was conducted, considering characteristics of person, time, HCWs category, and diagnostic test. The results of the tests of RSUH HCWs between March 2020 and March 2022 were analysed. Socio-demographic and clinical data were collected from the Alert Network of the Epidemiological Surveillance System of Andalusia.

Results: The study included 6,794 HCWs, of whom 1,513 (22.3%) tested positive for COVID-19. The distribution of COVID-19 cases among HCWs across the six waves was as follows: first wave – 150 cases (9.9%), second wave – 597 cases (39.4%), third wave – 225 cases (14.9%), fourth wave – 24 cases (1.6%), fifth wave – 121 cases (8%), and sixth wave – 396 cases (26.2%). The mean age of confirmed cases was 46.32 years (SD = 11.53), with a lower infection risk among HCWs aged 61–70 years. Only 16.9% of cases had received two vaccine doses at the time of infection. Nursing was the most affected professional category (30%).

Conclusions: COVID-19 infection risk varies by age and HCWs category, decreasing in older HCWs but increasing among residents and certain specialties. During the Omicron variant's dominance, vaccines seemed less effective in reducing transmission. Health education programmes for both patients and HCWs are necessary to limit the spread of the disease.

Key words: COVID-19, SARS-CoV-2, coronavirus infection, healthcare workers, incidence, risk factors

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INTRODUCTION

The repercussions of COVID-19 pandemic have affected numerous countries globally. Spain, among the European nations, faced severe consequences, reporting over 2.6 million patients in June 2023 (1). A noteworthy aspect finding was that about one-fourth of COVID-19 cases involved healthcare workers (HCWs). This highlights the unique risk posed to HCWs by the virus transmission mechanisms, making them particularly vulnerable to both contracting and spreading COVID-19. The seroprevalence of IgG-COVID-19 antibodies was higher in HCWs compared to the general population (2, 3).

Extensive efforts were made to identify optimal protection measures to minimize infections among HCWs. A study in Israel from March to May 2020 found that 75% of COVID-19 transmissions to HCWs happened when personal protective equipment

(PPE) was not used properly or at all. The study highlighted that consistently wearing masks significantly reduced virus spread. Surprisingly, the main source of infection for HCWs was not patients but co-workers, responsible for 58% of the cases. This underscores the importance of strict PPE use and infection control measures among HCWs to protect against COVID-19 (4).

These insights highlight the necessity of tailoring protective methods specifically for HCWs and exploring other potential contagion scenarios among colleagues. A systematic review and qualitative meta-synthesis emphasized that training for virus protection should account for factors such as work experience and previous training on PPE. Additionally, the study found that HCWs with high workloads and long shifts, who often desired adequate rest and recovery, frequently neglected basic protective measures, thereby putting themselves and their colleagues at risk (5).

The aim of the present study was to determine the incidence of COVID-19 infection among HCWs at Reina Sofia University Hospital (RSUH) in Cordoba, Spain, from the first to the sixth wave of the pandemic. Additionally, we analysed the characteristics of infections across different age groups, genders, professional categories, hospital services, and COVID-19 vaccination status.

MATERIALS AND METHODS

Study Design and Study Population

An observational, longitudinal, analytical, and retrospective study was conducted on a population of 6,794 HCWs from RSUH. The study period spanned from March 2020 to March 2022, covering the first to the sixth wave of the pandemic.

The study was conducted by the Department of Preventive Medicine and Public Health at RSUH, responsible for occupational health, particularly regarding infectious diseases and sickness absenteeism among HCWs. To ascertain details such as time worked, professional category, and hospital service, a comprehensive list of all RSUH HCWs was extracted from the Gerhonte system, a database maintained by the Andalusian Health Service, as of March 2022. The case definition covers any RSUH HCW who tested positive for COVID-19 during the study period.

The methods of detection of COVID-19 infection considered were:

- polymerase chain reaction (RT-PCR) of nasopharyngeal exudate;
- Panbio COVID-19 Ag nasopharyngeal swab;
- rapid detection test for antibodies in blood samples in the hospital setting;
- blood serology for detection of specific IgM antibodies.

The date of diagnosis was established as the first of the previous tests with a positive result, regardless of symptoms.

The source of information used for the description and statistical analysis of the HCWs cases was RedAlerta, which is the registry of the Epidemiological Surveillance System of Andalusia (SVEA).

The cumulative number of confirmed, hospitalized, intensive care unit (ICU) admitted and deceased cases was obtained from the “COVID-19 Report in Andalusia” prepared by the Health and Families Department and the Institute of Statistics and Cartography of Andalusia.

Data Collection and Variables

The variables studied were sex, age, age group, type of COVID-19 diagnosis, vaccination doses, date of diagnosis of the case, follow-up time to diagnosis, reinfection, professional category, and medical service. Age was categorized according to the following age groups: 18–30 years, 31–40 years, 41–50 years, 51–60 years, and 61–70 years. In the vaccination variable, the number of doses was combined with “past history” to account for confirmed cases that had previously contracted the infection, allowing for a more accurate analysis of the vaccination schedule.

Statistical Analysis

Qualitative data were defined as numbers and percentages. Chi-square test and Fisher’s exact test were used for comparison between categorical variables as appropriate. Quantitative data were tested for normality by Kolmogorov-Smirnov test. Normal distribution of variables was described as mean and standard deviation (SD), and independent sample t-test was used for comparison between groups. The adjusted risk factors for COVID-19 infection were obtained using logistic regression analysis. The dependent variable was the presence or absence of COVID-19 infection in all participants. All variables described previously were considered as possible candidates for the final model. P-value ≤ 0.05 was considered statistically significant. The collected data were introduced and statistically analysed by utilizing JAMOV version 2.3.2.

RESULTS

A total of 6,794 HCWs actively working during the pandemic were analysed between March 2020 and March 2022. Among them, 1,513 (22.3%) individuals tested positive for COVID-19. The mean follow up periods of all participants was 599.42 (SD = 166.44) days; 670 (SD = 0.01) among HCWs not infected and 353.06 (SD = 215.25) among HCWs with COVID-19 infection. The distribution of COVID-19 cases among HCWs across the six waves was as follows: first wave – 150 cases (9.9%), second wave – 597 cases (39.4%), third wave – 225 cases (14.9%), fourth wave – 24 cases (1.6%), fifth wave – 121 cases (8%), and sixth wave – 396 cases (26.2%). The majority of infections occurred during the second wave (39.5%) and the sixth wave (26.2%).

Table 1a and 1b examine the clinical variables of the subjects under study. Of the participants, 75.8% were women. The most common age group was 51–60 years, constituting 36.7%, while the least common was 18–30 years, accounting for 11.4%. The mean age of the professionals was 47.56 (SD=11.53) years. Concerning confirmed cases, the mean age was 46.32 (SD=11.53) years, with women also being the majority (76.7%). The most commonly used infection detection test was PCR (72.2%). Among all confirmed cases, the majority had received 2 vaccine doses at the time of infection (16.9%). There were 63 (4.2%) reinfections out of the 1,513 confirmed cases.

Table 2 presents the percentages of infections and re-infections among HCWs at RSUH across the six pandemic waves.

Table 3 provides a detailed analysis of the key variables related to the workplace. Nursing emerged as the most represented professional category (30%), with the “non-assistance” categorized services encompassing the highest number of professionals (28.7%).

In the multivariate model, as can be seen in Table 4, it was found that professionals aged between 61–70 years had a lower risk of infection (OR = 0.70, 95% CI: 0.52–0.93) when compared with HCWs aged between 18–30 years. It was also established that medical specialists (OR=1.43, 95% CI: 1.03–1.97) and medical residents (OR = 2.05, 95% CI: 1.34–3.12) had a higher risk of infection when compared with administrative assistants.

DISCUSSION

Our research aimed to assess the occurrence of SARS-CoV-2 infection and identify its risk factors among HCWs at RSUH of

Table 1a. Comparative analysis based on socio-demographic characteristics within the study cohort in relation to COVID-19 infection

COVID-19 cases	No infection n = 5,281 n (%)	COVID-19 case n = 1,513 n (%)	Total n = 6,794 n (%)	p-value
Sex				
Male	1,293 (24.5)	353 (23.3)	1,646 (24.2)	0.374
Female	3,988 (75.5)	1,160 (76.7)	5,148 (75.8)	
Age (years), mean (SD)	47.89 (11.51)	46.32 (11.53)	47.56 (11.53)	< 0.001
Age groups				
18–30 (reference)	569 (10.8)	189 (13.9)	758 (11.4)	< 0.001
31–40	808 (15.3)	209 (15.4)	1,017 (15.4)	
41–50	1,166 (22.1)	328 (24.1)	1,494 (22.6)	
51–60	1,945 (36.9)	488 (35.9)	2,433 (36.7)	
61–70	777 (14.8)	146 (10.7)	923 (13.9)	

Numbers in bold indicate statistically significant values.

Table 1b. Comparative analysis within the study cohort in relation to COVID-19 infection

COVID-19 cases	COVID-19 case n = 1,513 n (%)
PCR	1,093 (72.2)
Rapid antigen test	298 (19.7)
Serology	115 (7.6)
Rapid antibodies test	7 (0.5)
Vaccination doses	
0	56 (3.7)
Past history of infection	14 (0.9)
1	72 (4.8)
1 + past history of infection	6 (0.4)
2	256 (16.9)
2 + past history of infection	27 (1.8)
3	211 (13.9)
3 + past history of infection	19 (1.3)
Previous vaccination	852 (56.3)
Re-infection	
No	1,450 (95.8)
Yes	63 (4.2)

Córdoba from March 2020 to March 2022, resulting in the identification of 1,513 (22.3%) positive cases. Among the confirmed cases, 63 (4.2%) of them corresponded to reinfections.

Our univariate analysis indicates that there is no significant difference in terms of sex between COVID-19-infected HCWs and their controls, with percentages of 76.7% and 75.5%, respectively. Our multivariate analysis indicates that females had a higher risk of COVID-19 infection. This finding aligns with a previous systematic review and meta-analysis focusing on the risk of COVID-19 infection among HCWs, where a higher prevalence was noted among females (6).

Upon examining the age groups of confirmed cases, it becomes apparent that work experience appears to act as a protective factor against the transmission of the disease. In our study, the multivariate analysis reveals a greater incidence and infection rate among residents compared to other healthcare professionals, with the 61–70 age group exhibiting the lowest infection rates, consistent with findings from previous studies (7–9).

PCR has been considered the best method since the beginning of the pandemic (10). However, due to the need for quick detection and sometimes limited availability of PCR tests, other diagnostic tests recommended by health authorities were used. These tests were easily accessible to the public and more widely available in the community (11). In our hospital, despite some minor variations, PCR has been the most common test (72.2%) for diagnosing positive cases.

Table 2. Distribution of COVID-19 infections and re-infections among professionals across the six waves

Wave	Number of COVID-19 cases n (%)	New infection (%)	Re-infection (%)
First wave	150 (9.9)	9.9	0.0
Second wave	597 (39.4)	39.1	0.3
Third wave	225 (14.9)	14.3	0.6
Fourth wave	24 (1.6)	1.5	0.1
Fifth wave	121 (8.0)	7.7	0.3
Sixth wave	396 (26.2)	23.2	3.0
Total	1,513 (100.0)	95.7	4.3

Table 3. Comparative analysis of professional characteristics within the study cohort in relation to COVID-19 infection

COVID-19 cases	No infection n = 5,281 n (%)	COVID-19 case n = 1,513 n (%)	Total n = 6,794 n (%)	p-value
Professional category groups				
Administrative assistant	364 (6.9)	80 (5.3)	444 (6.5)	<0.001
Medical specialist	736 (13.9)	219 (14.5)	955 (14.1)	
Nurse	1,588 (30.1)	452 (29.9)	2,040 (30.0)	
Resident physician/nurse	239 (4.5)	121 (8.0)	360 (5.3)	
Nurse assistant	1,087 (20.6)	305 (20.2)	1,392 (20.5)	
Health technician	197 (3.7)	59 (3.9)	256 (3.8)	
Porter	430 (8.1)	118 (7.8)	548 (8.1)	
Laundry/cleaning	95 (1.8)	43 (2.8)	138 (2.0)	
Other technician	545 (10.3)	116 (7.7)	661 (9.7)	
Medical services				
Physician non-assistance	1,550 (29.4)	401 (26.5)	1,951 (28.7)	0.004
Obstetrics and gynaecology	253 (4.8)	64 (4.2)	317 (4.7)	
Internal medicine	1,415 (26.8)	449 (29.7)	1,864 (27.4)	
Paediatrics	283 (5.4)	64 (4.2)	347 (5.1)	
Surgery	688 (13.0)	237 (15.7)	925 (13.6)	
ICU/anaesthesia	1,092 (20.7)	298 (19.7)	1,390 (20.5)	

Numbers in bold indicate statistically significant values.

Vaccination campaigns have undeniably contributed to reduced mortality associated with COVID-19 infection (12). However, there are uncertainties regarding whether, beyond affecting mortality rates, these measures have significantly curbed the transmission of the virus. Our study reveals an elevated incidence of the disease in December 2021, accompanied by a heightened number of reinfections during the sixth wave. This aligns with the emergence of the Omicron variant in our country, marking a paradigm shift in the national and global scenario. The variant demonstrated a substantial increase in infections and reinfections, even among individuals who were already vaccinated (13, 14). This might suggest that the effectiveness of the vaccine may not primarily lie in reducing the spread of the virus, as indicated by earlier studies (15, 16).

Unfortunately, we could not include data on virus subtypes, as after the first wave the hospital and health system no longer requested subtype identification for affected patients, including HCWs. The frequency of cases among HCWs undoubtedly varied across successive waves, reflecting the adoption and evolution of different protective measures.

Regarding the impact of vaccination, type of vaccine, or previous infection, no study to date has been able to clearly attribute the reduction in case numbers or infection risk to a single factor. The most probable explanation is the interaction between all these elements.

Our results showed a notable variation in the risk of contracting the infection across different occupational categories. Nurses and assistant nurses were the most frequent HCWs category who suffered in our cohort from COVID-19 infection. This could be explained by the fact that most nurses and assistant nurses are females, a risk factor that has been observed previously. Additionally, they

typically have close contact with patients, particularly those admitted with advanced illnesses. Consistent with our findings, previous studies have also reported that assistant nurses and nursing staff face a higher risk of infection compared with other HCWs (17–19).

Our univariate and multivariate analyses did not reveal any specific medical specialty to be linked with a higher risk of COVID-19 infection. In contrast to our findings, a systematic review and meta-analysis proposed that elevated infection rates were connected to working in operating rooms/surgeries (24%, 95% CI: 17–31) and working in non-emergency units during screening (43%–72.2%) (20).

This research is distinguished by its extensive sample size, abundant data, and high confidence levels. Nevertheless, it also comes with certain limitations. Firstly, the samples exclusively originate from a single hospital, introducing a possible bias towards that particular centre. Secondly, the diversity of laboratory tests used for the diagnosis of COVID-19, as well as the study variables, lacks comprehensiveness.

CONCLUSION

Our study highlights varying susceptibility to COVID-19 among HCWs, emphasizing the need for tailored preventive measures for specific professional categories like nurses, assistant nurses, and medical residents. Older HCWs exhibit a lower infection risk, likely due to their experience with personal protective equipment and heightened infection awareness. Most reinfections occurred during the sixth wave, even among professionals with 2–3 vaccine doses, indicating breakthrough cases. This emphasizes the ongoing need for

Table 4. Logistic regression analysis for identification of risk factors associated with COVID-19 infection

Predictive factor	Crude OR	Adjusted OR (95% CI)	p-value
Sex			
Male (reference)	1	1	–
Female	1.065	1.171 (1.005–1.365)	0.044
Age groups			
18–30 (reference)	1	1	–
31–40	0.779	0.905 (0.698–1.174)	0.451
41–50	0.847	1.026 (0.797–1.322)	0.84
51–60	0.755	0.942 (0.735–1.207)	0.637
61–70	0.566	0.698 (0.523–0.932)	0.015
Professional category groups			
Administrative assistant (reference)	1	1	–
Medical specialist	1.354	1.427 (1.032–1.974)	0.032
Nurse	1.295	1.299 (0.954–1.769)	0.096
Resident physician/nurse	2.304	2.047 (1.344–3.118)	<0.001
Nurse assistant	1.277	1.28 (0.935–1.753)	0.123
Health technician	1.363	1.242 (0.818–1.884)	0.31
Porter	1.249	1.337 (0.941–1.899)	0.105
Laundry/cleaning	2.059	1.433 (0.874–2.349)	0.154
Others technician	0.968	0.947 (0.681–1.318)	0.748
Medical services			
Physician non-assistance (reference)	1	1	–
Obstetrics and gynaecology	0.978	0.848 (0.606–1.189)	0.339
Internal medicine	1.227	1.05 (0.856–1.288)	0.642
Paediatrics	0.874	0.712 (0.507–1.000)	0.05
Surgery	1.332	1.122 (0.888–1.418)	0.333
ICU/anaesthesia	1.055	0.909 (0.726–1.139)	0.409

Numbers in bold indicate statistically significant values.

monitoring and adjusting vaccination strategies within the healthcare workforce. Finally, the emergence of the Omicron variant revealed that vaccines do not fully prevent infections among HCWs, reflecting trends in the general population. This underscores the challenges posed by evolving variants and reinforces the importance of robust public health measures alongside vaccination efforts.

Conflicts of Interest

None declared

Adherence to Ethical Standards

This study was approved by the Research Ethical Committee of Cordoba, Spain, (23 February 2022, code no. TFG-HURS-2021). Written informed consent was obtained from all participants. This study was executed according to the code of ethics of the World Medical Association (Declaration of Helsinki) for studies on humans.

Data Availability

The datasets generated and/or analysed during current study are available from the corresponding author on reasonable request.

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