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Risk of COVID-19 in healthcare workers working in intensive care setting

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A B S T R A C T

Background: The higher risk of COVID-19 in health care workers (HCWs) is well-known. However, the risk within HCWs is not fully understood. The objective was to compare the COVID-19 risk in intensive care unit (ICU) vs non-ICU locations.

Methods: A prospective surveillance study was conducted among HCWs at a large tertiary care facility in Riyadh between March 1st to November 30th, 2020. HCWs included both clinical (provide direct patient care) and nonclinical positions (do not provide direct patient care).

Results: A total 1,594 HCWs with COVID-19 were included; 103 (6.5%) working in ICU and 1,491 (93.5%) working in non-ICU locations. Compared with non-ICU locations, ICU had more nurses (54.4% vs 22.1%, $P < .001$) and less support staff (2.9% vs 53.1%, $P < .001$). COVID-19 infection was similar in ICU and non-ICU locations (9.0% vs 9.8%, $P = .374$). However, it was significantly higher in ICU nurses (12.3% vs 6.5%, $P < .001$). Support staff had higher risk than other HCWs, irrespective of ICU working status (15.1% vs 7.2%, $P < 0.001$). The crude relative risk of COVID-19 in ICU vs non-ICU locations was 0.92, 95% confidence interval (was 0.76-1.11 ($P = .374$). However, relative risk adjusted for professional category was significantly increased to 1.23, 95% confidence interval 1.01-1.50 ($P = .036$).

Conclusions: ICU had a significantly higher risk of COVID-19 infection only after adjusting for the distribution and risk of different professional categories. The latter is probably determined by both exposure level and protection practices. The finding underscores the importance of strict implementation of preventive measures among all HCWs, including those performing nonclinical services.

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Health care workers (HCWs) around the world are facing considerable physical and mental challenges during the current coronavirus disease (COVID-19) pandemic.¹ In addition to the traditional community risk, they suffer from additional higher risk of exposure at health

care setting.^{2,3} In relatively few HCWs, this may end up with hospital admission and even death. Being in the frontline of the fight against COVID-19, HCWs are at higher risk of burnout, psychological comorbidities, and sleep disturbance.^{4,5} Additionally, they may act as a

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source of infection to their patients, colleagues, and households.⁶ In Saudi Arabia, the burden of COVID-19 among HCWs is not well defined. Two recently published seroprevalence studies showed that neutralizing antibodies were present in 2.4% of HCWs in May 2020 and in 6.3% of HCWs during June and July 2020.^{7, 8} However, the real burden of COVID-19 infection in HCWS is probably much higher and increasing overtime.^{7, 8}

While the higher risk of COVID-19 in HCWs is clear, the risk within the HCWs is not that clear. The US Occupational Safety & Health Administration classified the exposure risk in HCWs based on performed activities, with those performing aerosol-generating procedures were classified as very high risk.⁹ Later, it was recommended to include personal information in addition to professional category in determining the professional risk of COVID-19 in HCWs.¹⁰ Previous studies showed that risk of COVID-19 infection was highest in specific professional category, such as nurses^{11–13} and allied health care.^{13–15} Additionally, these reports showed that the risk was highest in specific hospital locations, such as non-emergency wards^{11, 15} and nonintensive care units (ICUs).^{13–15} The objective of the current study was to compare the COVID-19 risk in HCWs working in ICU and non-ICU locations in a tertiary care hospital. Additionally, to examine the interaction between hospital locations and professional category.

METHODS

Setting

The current study was conducted at King Abdulaziz Medical City at Riyadh (KAMC-R), Saudi Arabia, which is an approximately 1,488-bed tertiary care facility, composed of 2 hospitals. The facility provides health care services for almost 1.15 million eligible Saudi National Guard soldiers, employees and their families. The facility had a total 172 (11.6%) intensive care beds and 168 (11.3%) emergency beds. According to local hospital statistics, KAMC-R received 55,025 admissions and served 863,073 outpatient clinic visits in 2019. The facility is served by 16,317 HCWs; including 2,451 physicians, 5,483 nurses, and 3,101 other clinical HCWs, and 5,282 administrative and support jobs that involve no direct patient care.

Study design

The current study design was a prospective surveillance study for all HCWs confirmed with COVID-19 at KAMC-R during the pandemic period; March 1st to November 30th, 2020. The study obtained all required ethical approvals from the institutional review board of King Abdullah International Medical Research Center, Riyadh, Saudi Arabia. This project received the approval of the Research Ethics Committee of King Abdullah International Medical Research Center (protocol reference number RC20/563/R). The Research Ethics Committee waived the need for informed consent.

Definitions

The case definition used was based on the definition released by the Saudi Ministry of Health and the Saudi Center for Disease Prevention and Control.¹⁶ Only confirmed cases who had a positive RT-PCR test for COVID-19 were included in the study. The study outcomes included COVID-19 infection and related outcomes including hospitalization, ICU admission, case fatality, and mortality. HCW were defined as all staff who were working within the hospital premises. They included both clinical (provide direct patient care) and non-clinical positions (do not provide direct patient care). Clinical positions included physicians, nurses, and other HCWs. The later included

technicians, technologist, pharmacists, physiotherapist, dental assistants, and other allied health care positions. Nonclinical positions included administrative, service, logistic, maintenance, security, and research positions.

Case finding

HCWs who were meeting the suspected COVID-19 definition or as part of contact tracing had their nasopharyngeal swabs examined using RT-PCR test for COVID-19. Suspected COVID-19 definition included those with acute respiratory symptoms even without epidemiologic link (contact with a confirmed case or recent travel to an infected area).¹⁰ Contact tracing was usually initiated after unprotected exposure to confirmed patient or HCWs.

Statistical methods

Categorical variables were presented as frequencies and percentages while continuous variables were presented as means and standard deviations. Epidemic curves for HCWs and patients at KAMC-R were plotted. Demographic and professional characteristics as well as outcomes were compared by ICU working status. Chi-square test or Fisher's exact test, as appropriate, were used to compare categorical variables. T-Test was used to compare continuous variables. Crude and Mantel-Haenszel adjusted relative risk (RR) of COVID-19 among HCWs was calculated for HCWs with ICU vs non-ICU working status. Mantel-Haenszel Chi-square was used to examine the difference between ICU and non-ICU HCWs after adjusting for professional category. All *P*-values were 2-tailed. A *P*-value < .05 was considered significant. Statistical Package for the Social Sciences software (SPSS Version 27.0. Armonk, NY: IBM Corp) were utilized for statistical analysis.

RESULTS

During the 9 months period of the study, a total 1,594 HCWs have been confirmed with COVID-19 after 8,130 RT-PCR tests done at the KAMC-R between March and November 2020. On average, 5.1 tests were done for each positive HCW. Out of 1,594 HCWs included, 103 (6.5%) working in ICU and 1491 (93.5%) working in non-ICU locations (Table 1). The mean age was 38.0 ± 9.9 years, with no significant difference between the 2 groups (*P* = .577). The majority of HCWs at KAMC-R were males (56.9%) and non-Saudi (58.5%). However, females (60.2% vs 41.9%, *P* < .001) and non-Saudi (78.6% vs 57.0%, *P* < .001) were more represented in ICU compared with non-ICU locations. Professional category was different between groups (*P* < .001). Nurses were the major (54.4%) professional category in ICU, followed by other HCW (29.1%), physicians (13.6%), and support staff (2.9%). On the other hand, support staff were the major (53.1%) professional category in non-ICU locations, followed by nurses (22.1%), other HCW (13.2%), and physicians (11.6%). Hospital-acquired transmission was the most frequent probable source of infection in both groups (55.3% and 47.6%, respectively, *P* = .142). Hospital admission were similar in both groups (1.9% in each) while ICU admission was slightly higher (but not significant) in ICU compared with non-ICU locations (1.9% vs 0.3%, *P* = .070). Overall mortality in HCWs was very low (0.1%) with no deaths in ICU.

As shown in Table 2, the incidence of COVID-19 infection was similar in HCWs working in ICU and non-ICU locations (9.0% vs 9.8%, *P* = .374) when all HCWs irrespective of their professional category were considered. However, the risk of infection was significantly higher among nurses working in ICU compared with non-ICU locations (12.3% vs 6.5%, RR = 1.88, *P* < .001). Additionally, there was trend of lower risk of infection among physicians working in ICU compared with non-ICU locations (4.9% vs 8.0%, RR = 0.62, *P* = 0.071).

Table 1
Demographic and professional characteristics as well as outcomes among health care workers (HCWs) by intensive care unit (ICU) working status (March to November 2020)

Variable	ICU work (N = 103)	Non-ICU work (1,491)	Total (N = 1,594)	P-value
Age				
Mean±SD	38.0 ± 10.1	38.5 ± 8.0	38.0 ± 9.9	.577
<30	639 (43.2%)	40 (38.8%)	679 (42.9%)	.387
30-45	504 (34.1%)	42 (40.8%)	546 (34.5%)	
>45	335 (22.7%)	21 (20.4%)	356 (22.5%)	
Gender				
Male	41 (39.8%)	859 (58.1%)	900 (56.9%)	<.001
Female	62 (60.2%)	619 (41.9%)	681 (43.1%)	
Nationality				
Saudi Arabia	22 (21.4%)	634 (43.0%)	656 (41.5%)	<.001
Non-Saudi	81 (78.6%)	842 (57.0%)	923 (58.5%)	
Professional category				
Nurse	56 (54.4%)	329 (22.1%)	385 (24.2%)	<.001
Physician	14 (13.6%)	173 (11.6%)	187 (11.7%)	
Other HCW	30 (29.1%)	197 (13.2%)	227 (14.2%)	
Support staff	3 (2.9%)	792 (53.1%)	795 (49.9%)	
HCW type				
Clinical	100 (97.1%)	699 (46.9%)	799 (50.1%)	<.001
Non-clinical	3 (2.9%)	792 (53.1%)	795 (49.9%)	
Symptoms				
Asymptomatic	16 (17.0%)	310 (22.3%)	326 (22.0%)	.233
Symptomatic	78 (83.0%)	1,081 (77.7%)	1,159 (78.0%)	
Probable source of infection				
Community-acquired	32 (31.1%)	466 (31.3%)	498 (31.2%)	.142
Hospital-acquired	57 (55.3%)	709 (47.6%)	766 (48.1%)	
Unknown	14 (13.6%)	316 (21.2%)	330 (20.7%)	
Hospital admission				
No	101 (98.1%)	1,463 (98.1%)	1,564 (98.1%)	>.99
Yes	2 (1.9%)	28 (1.9%)	30 (1.9%)	
ICU admission				
No	101 (98.1%)	1,486 (99.7%)	1,587 (99.6%)	.070
Yes	2 (1.9%)	5 (0.3%)	7 (0.4%)	
Death				
No	103 (100.0%)	1,489 (99.9%)	1,592 (99.9%)	>.99
Yes	0 (0.0%)	2 (0.1%)	2 (0.1%)	

Support staff had higher risk than other HCWs, irrespective of ICU working status (15.1% vs 7.2%, $P < 0.001$).

As shown in Figure 1, crude RR of infection among HCWs working in ICU compared with non-ICU locations irrespective of their professional category was 0.92, 95% confidence interval (CI) was 0.76-1.11, and $P = .374$. After adjusting for professional category, the RR of

infection significantly increased to 1.23, with 95% confidence interval 1.01-1.50, and $P = .036$.

Figure 2 shows the epidemic curve of confirmed COVID-19 infection for HCWs by ICU working status and for patients by ICU admission status. Irrespective of the small number of HCWs working in ICU compared with other groups, the epidemic curves of the 4 groups

Table 2
Incidence of COVID-19 among health care workers (HCWs) by intensive care unit (ICU) working status and professional categories (March to November 2020)

Variable	Frequency	COVID-19 incidence	Relative risk (RR)*	Confidence interval	P-value [†]
Nurse					
ICU	455 (8.3%)	56 (12.3%)	1.88	1.44-2.46	<.001
Non-ICU	5,028 (91.7%)	329 (6.5%)			
Total	5,483 (100.0%)	385 (7.0%)			
Physician					
ICU	283 (11.5%)	14 (4.9%)	0.62	0.36-1.05	.071
Non-ICU	2,168 (88.5%)	173 (8.0%)			
Total	2,451 (100.0%)	187 (7.6%)			
Other HCW					
ICU	373 (12.0%)	30 (8.0%)	1.11	0.77-1.61	.568
Non-ICU	2,728 (88.0%)	197 (7.2%)			
Total	3,101 (100.0%)	227 (7.3%)			
Support staff					
ICU	30 (0.6%)	3 (10.0%)	0.66	0.23-1.94	.632
Non-ICU	5,252 (99.4%)	794 (15.1%)			
Total	5,282 (100.0%)	797 (15.1%)			
Total					
ICU	1,141 (7.0%)	103 (9.0%)	0.92	0.76-1.11	.374
Non-ICU	15,176 (93.0%)	1,493 (9.8%)			
Total	16,317 (100.0%)	1,596 (9.8%)			

*RR refers to risk in ICU compared with non-ICU HCWs.

[†]P-values were calculated using Chi-square test or Fisher.

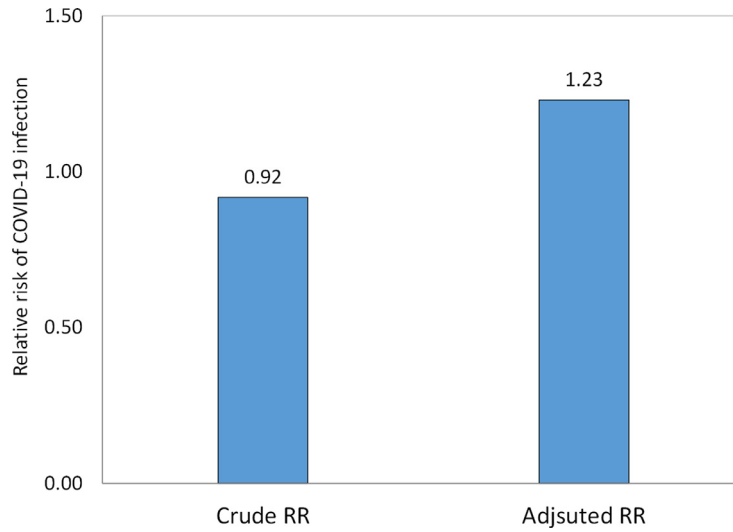


Fig 1. Risk of COVID-19 among HCWs working in ICU compared with non-ICU locations at KAMC-R before (crude RR) and after (adjusted RR) adjusting for professional categories
 Note: Chi-square ($P = .374$) was used for crude RR while Mantel-Haenszel Chi-square ($P = .034$) was used for adjusted RR

were almost identical with a peak in June 2020. The curves between August and November were slightly decreasing in all groups except for HCWs working in ICU. The rising curve in November among HCWs working in ICU was caused by a cluster of COVID-19 infection among nurses working in ICU ($N = 9$).

DISCUSSION

The current study compared the risk of COVID-19 infection among HCWs working in ICU compared with non-ICU locations in a tertiary care setting. The risk in ICU was similar or slightly lower when professional category is ignored and was significantly higher when professional category is adjusted for. This may be explained by the clear differences in the distribution and risk of HCWs of different professional category inside and outside the ICU. Overrepresentation of nurses in ICU tended to raise the risk while the underrepresentation of support staff in ICU tended to reduce the risk. For example, nurses who were the only professional category

that had significantly higher risk in ICU compared with non-ICU locations represented 54% of HCWs working in ICU compared with 22% in HCWs working in non-ICU locations. On the other hand, support staff who had the highest frequency of COVID-19 infection among all professional categories represented only 3% of HCWs working in ICU compared with 53% in HCWs working in non-ICU locations. Previous studies showed generally lower risk of COVID-19 infection in ICU compared with hospital wards.^{13–15} For example, Brousseau and colleague reported lower risk in ICU (6.2%) compared with wards (13%-20%) in 10 hospitals in Canada.¹⁴ Similarly, Patel and colleagues reported significantly lower risk of COVID-19 infection in ICU (23%) compared with general wards (43%) in a large trust in UK.¹³ The lower risk in ICU in these studies has been explained by the strict use of personal protective equipment (PPE).^{13–15} Additionally, ICU patients with COVID-19 who typically staying longer than a week have reduced infectiousness after the first week of disease.¹⁷ However, the authors in the above studies did not adjust for the professional category.^{13–15}

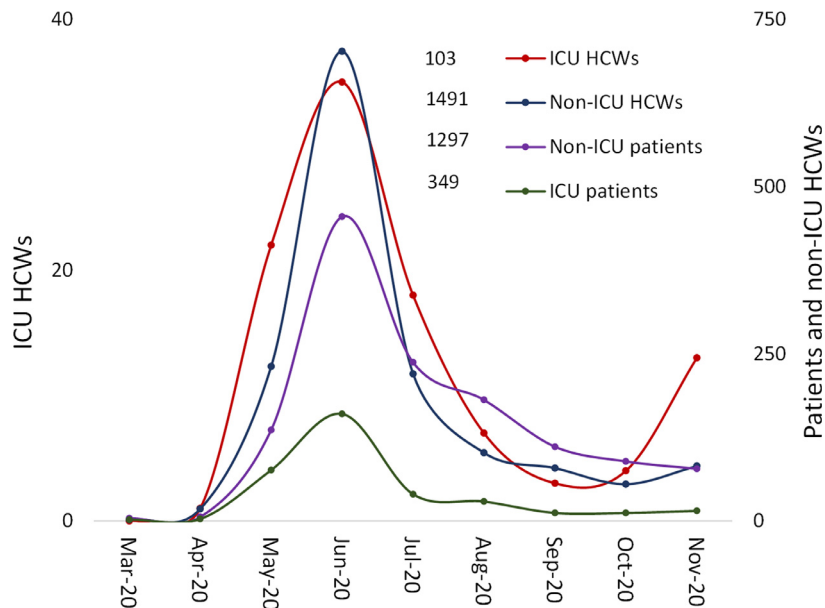


Fig 2. Epidemic curve of confirmed COVID-19 infection in HCWs (by ICU working status) and patients (by ICU admission status) at KAMC-R, March to November 2020

Previous studies pointed to the higher risk of infection in nurses, but without differentiating between ICU and non-ICU locations.^{11–13} The current study showed higher risk of COVID-19 infection in ICU nurses, which may be related to heavier exposure to sick ICU patients, who required extensive care, frequent bedside tasks, multiple medications, and continuous observation.¹¹ While the viral shedding is decreasing overtime, it is typically longer in ICU and more severe patients compared with non-ICU and milder patients.¹⁷ It has been pointed that strict use of PPE can abolish the higher COVID-19 risk among ICU nurses.¹⁸ Although HCWs in our hospital including nurses in both ICU and non-ICU settings were required to wear full PPE while dealing with COVID-19 patients, PPE compliance data were not monitored. Additionally, our hospital faced a significant shortage of COVID-19 trained nurses which was fixed by quick training of nurses in other services.¹⁹ Finally, the nursing cluster towards the end of the study pointed to the possibility of transmission between HCWs during dining and socializing, when minimal preventive measures are implemented.²⁰ On the other hand, the observed trend of lower risk of COVID-19 infection among ICU physicians in the current study may be related their younger age and largely remote care used during the pandemic. The ICU at KAMC-R is a big training center for physician; with 84% the physician's workforce during 2020 were residents, interns, and fellows.

The higher risk of COVID-19 infection among the support staff in the current study was unexpected. Several studies pointed to the lower^{12, 13, 15} or similar^{21–23} risk of COVID-19 infection among nonclinical HCWs compared with clinical HCWs. Obviously, nonclinical HCWs have lower exposure level as they are not involved in direct patient care. However, they probably have a limited knowledge about protecting themselves during the pandemic.²⁴ It has been reported that the compliance with hand hygiene and the use of PPE was lower in non-clinical compared with clinical staff.²⁵ Additionally, the lower perceived risk among nonclinical staff may lead to loose adherence to preventive measures such as wearing masks and social distancing,²⁶ specially many of them were living in shared residence provided by the hospital. Additionally, subanalysis of the current data showed significantly higher community source of infection in support staff than other professional categories. The current finding may indicate the need of strict implementation of preventive measures among all HCWs, including those performing non-clinical services.

The epidemic curve for HCWs working in ICU was identical to the epidemic curves of ICU patients, non-ICU patients, and non-ICU HCWs; all had the peak in June 2020. This finding is probably consistent with the selfreported health care exposure, which was the major reported source of infection in the current HCWs, irrespective of ICU working status. Interestingly, the above health care epidemic curves were also similar to that of Saudi Arabia, with the peak in June 2020.²⁷ This may underscore the role of community exposure in HCWs' risk of infection. Similarly, previous studies showed that the epidemic curve of HCWs was similar to that of the patients and community.^{6, 12, 28} It should be noted that confirming the health care and/or community exposure is very difficult, especially in the middle of pandemic.

The current study is considered the first local and/or regional study to comprehensively compare the risk of COVID-19 infection among HCWs by ICU working status. Additionally, it is the only study so far to adjust ICU risk by the professional category. However, lack of detailed clinical information and compliance with PEE did not allow us to adjust for individual risk. Despite being a large tertiary care facility composed of 2 hospitals, the findings should be generalized with caution to other hospitals.

In conclusion, the risk of COVID-19 infection in HCWs working in ICU was similar or slightly lower when professional category is ignored and was significantly higher when professional category is adjusted for. The risk was significantly higher among ICU nurses and there was a trend of lower risk in ICU physician. Support staff had the highest risk irrespective of ICU working status. The differential risk by professional category is probably determined by both exposure level and protection practices. The finding underscores the importance of strict implementation of preventive measures among all HCWs, including those performing non-clinical services.

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