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Highlights:

- Clustering of COVID-19 is frequent among healthcare workers.
- Hospital-provided shared accommodation and social gatherings were associated with clustering of infection.
- Caring for COVID-19 patients is not associated increased risk of infection when resources are available.
- Community exposures pose significant risks of infection to healthcare workers.

Clustering of Covid-19 Infections among Healthcare Workers: Experience from A Tertiary Care Center in Saudi Arabia

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Conflicts of interest:

All authors declare that they have no conflicts of interest.

Abstract

Introduction

Coronavirus infectious disease 2019 (COVID-19) had a significant impact on healthcare workers (HCWs) worldwide. Understanding the dynamics of infection transmission is important to develop strategies to prevent its spread.

Methods

A retrospective study of a cohort of HCWs with COVID-19 from a single tertiary care hospital during the first wave of the pandemic. Epidemiological investigations and identification of clusters of infection were done prospectively.

Results

A total of 326 HCWs had COVID-19 based on positive polymerase chain reaction tests for SARS-CoV-2. Ten clusters of infection were identified; nine clusters had HCWs as the index cases while one cluster had a patient as the index case. The largest cluster involved 15 transmissions, and one cluster included a secondary transmission. Sharing accommodation and social gatherings were the commonest epidemiological links. The majority of infected HCWs had mild infections, 23 (6%) required hospital admission and 3 (1%) required intensive care; all fully recovered. Majority of infections (80%) were community-acquired. Living in shared accommodation was associated with COVID-19 (120/690 versus 206/1610, P value = 0.01) while working in COVID-19 designated wards/units was not associated with COVID-19 (52/297 versus 274/2003, p value = 0.13).

Conclusions

Clustering of COVID-19 was common among HCWs and related to shared accommodation and social gatherings, infection was of mild severity, and was not associated with caring for COVID-19 patients.

Key words: COVID-19; SARS CoV2; Healthcare workers; Cluster; Hospital-acquired.

Introduction:

A novel coronavirus was first identified in Wuhan, China in January, 2020, after investigating a cluster of pneumonia due to unknown etiology. The virus was named as Severe Acute Respiratory Syndrome Coronavirus 2 (SARS CoV-2) and the disease was named as the Coronavirus Infectious Disease 2019 (COVID-19). The WHO declared it a pandemic on March 11, 2020 (1). As of April 13, 2022, the WHO has reported more than 499 million infections globally with more than 6 million deaths (2).

Healthcare workers (HCWs) were identified early in the pandemic to be at higher risk of contracting COVID-19 infection (3) (4). Protection of HCWs from being infected during pandemics is very important not only to preserve their lives, but also because they are the most important asset to combat pandemics and to sustain healthcare systems. Therefore, measures and tools to protect HCWs from getting infected should be identified and implemented early in any pandemic. Furthermore, the dynamics of infection transmission should be identified and potential sources of outbreaks among HCWs should be recognized and mitigated.

The first case of COVID-19 was reported in Saudi Arabia in March 2020 in a patient in Eastern Saudi Arabia (5). Subsequently, the country took several steps to mitigate the risk of infection including quarantines, curfew, and suspension of international flights (6). The current study aims to shed light on the causes, frequency, and magnitude of clustering of infection among HCWs in healthcare facilities and to report the experience from a center where a significant number of HCWs live in shared accommodations.

Methods:

This is a retrospective study conducted in Almoosa Specialist Hospital (ASH) during the first wave of COVID-19 pandemic that spanned the period from April 1, 2020, to September 30, 2020. All healthcare workers (HCWs) who had SARS-CoV-2 infection diagnosed by a positive real time polymerase chain reaction (PCR) test from a nasopharyngeal swab were included in the study. RT-PCR for SARS-CoV-2 was done as described previously (5). Data were retrieved from the patients' medical records and the infection control files and included patients' demographics, comorbid conditions, obesity, type of infection, hospital admission, course of infection, outcomes, and residual symptoms. All confirmed cases were investigated immediately in real time by the infection control team with special attention to the determination of the source of acquisition (community versus hospital-acquired), chronology of cases, and potential exposures to other infected patients, staff, friends, and family members. All infected HCWs were followed until their clinical conditions improved and they returned to work after recovery. A final follow up phone call was made to all infected HCWs to detect the presence of persistent symptoms up to 10 weeks after the infection was diagnosed.

A cluster was defined as the occurrence of 2 or more COVID-19 infections in HCWs or patients after exposure to one common source. Clusters of infection were identified based on the epidemiological investigation of each case that was done soon after the diagnosis was confirmed. Timeline depiction graphs were used each time a cluster was suspected. The cluster index case was identified based on the date of onset of symptoms not on the date of diagnosis. Excel sheets were developed and included all positive COVID-19 cases whether patients or staff and were updated on daily basis. Contact tracing was done for each infected patient or HCW. All individuals (patients or HCWs) who were determined to have had unprotected exposures to any newly diagnosed COVID-19 case underwent further testing by PCR whether symptoms were present or not. Pertinent exposures within the hospital and in the community were assessed based on the presence of a previously identified positive case, the type of exposure to that case, whether the exposure was protected or unprotected, and the duration and location of the exposure. HCWs were considered to have hospital-acquired infections if they had a known unprotected exposure to a patient, or if they worked in a high-risk area where COVID-19 patients were likely to be encountered even without a known hospital source exposure but in the absence of another known community exposure. Community-acquired infections were considered: 1) if the HCW employee had a known exposure outside the hospital, 2) if exposure to infected colleagues occurred outside work-related activities, and 3) in those without known exposures and who worked in areas where exposures to COVID-19 infected patients were not likely.

ASH represents a unique healthcare system where the 2300 employees come from thirty different countries in addition to Saudi Arabia, and 690 (30%) live in hospital-provided shared accommodations;

the latter creates additional challenges in controlling the spread of SARS-CoV-2 infection. Measures that were taken to mitigate the risk of infection to HCWs included dedicating medical wards and an intensive care unit with 20 bed capacity to serve COVID-19 patients, increase the emergency room capacity and provide areas for triaging of patients with respiratory symptoms, provide and maintain enough supplies of all required personal protective equipment (PPE) including the N95 respirators, educate and train staff on the proper use of PPEs, do N95 respirator fit-testing for all staff who dealt with COVID-19 infected/potentially infected patients, reallocation of staff in shared accommodations to have all staff from the same unit/department in the same accommodation if they live in shared accommodation to prevent inter-departmental spread of infection, allow employees to work from home when possible, limit work-related and social gatherings inside and outside the hospital, conduct only virtual meetings and activities, and apply universal masking in all hospital premises. In addition, and in order to deal with infected and possibly infected HCWs from shared accommodations, HCWs with fever and/or respiratory symptoms were isolated in a special building with a thirty-bed capacity designated for those with suspected infection only, and when confirmed, they were moved to a 64-bed isolation building that was designated for infected HCWs with mild illnesses who otherwise didn't require medical care. Finally, a 35-bed field hospital was created to provide care for infected HCWs and patients who only required minimal supplemental oxygen (up to 3 liters) and limited medical care, and was also used as a step-down for staff who clinically improved but continued to require oxygen. Figure 1 provides the dynamic flow of infected HCWs in the different COVID-19 allocated premises.

ASH had a total of 200 beds including 74 intensive care beds. The infection control program consisted of a director, five infection control practitioners, one employee-health clinic physician and one nurse. ASH facility adheres to local and international standards of care and has received accreditation and reaccreditation from the Joint Commission International (JCI), Saudi Central Board for Accreditation of Healthcare Institutions (CBAHI), and the College of American Pathologists (CAP). During the study period, a total of 2524 cases with laboratory confirmed COVID-19 infection were diagnosed in our hospital; this includes infected HCWs and 764 cases that were admitted to our facilities.

Simple statistics were used in describing the findings of the study. A p value of 0.05 or less was considered statistically significant. The study was approved by the ASH IRB committee.

Results:

During the first wave of the pandemic, a total of 326 HCWs were diagnosed to have COVID-19 infection; this represented 14% of the total number of ASH employees. The majority were young and 266 (82%) were less than 40 years of age. Of the cases, 205 (63%) were non-Saudis and 185 (57%) were female. A minority (51, 16%) had one or more underlying comorbid conditions, 102 (31%) were obese, and 34 (10%) were smokers. The majority of employees had mild infections; 237 (73%) had upper respiratory infection (URI), 21 (6%) had fever or other mild symptoms, and 36 (11%) were asymptomatic. On the other hand, more serious infections developed in 32 (10%) patients; 29 (9%) had pneumonia and 3 (1%) developed adult respiratory distress syndrome (ARDS). Hospital admission was required in 23 patients (6%) with 3 (1%) requiring intensive care unit admission. The majority were admitted to the field hospital (146, 35%) or the designated isolation building (128, 31%), while 116 (28%) patients were isolated in their homes. All patients recovered and none died. Persistent symptoms were documented in 121 (37%) employees with persistent cough and residual respiratory symptoms being the most common reported symptoms (41, 13%). Finally, a total of 4235 sick leave days were given in total, with an average of 13 days per employee. Table 1 summarizes the clinical characteristics of all COVID-19 infected HCWs.

Epidemiological investigations of the COVID-19 infections among our HCWs showed that clustering of infections was frequently encountered; 55 infections (17%) were part of transmissions in clusters. Living in a shared accommodation was found to be associated with an increased risk of COVID-19 infection;

120/690 HCWs living in shared accommodations had SARS-CoV-2 infection versus 206/1610 living in private accommodations (P value = 0.01). Numerically, HCW with direct patient contact (182, 56%) constituted the majority of infected HCWs, followed by supportive services (78, 24%), and those in administration (65, 20%). HCWs assigned to COVID-19 designated wards or units were not found to be at an increased risk of acquiring the infection versus other HCWs (52/279 versus 274/2003, p value = 0.13). Furthermore, infections among HCWs related to direct patient care were documented in 63 (19%) cases, and only 3 HCWs had known unprotected exposures to infected patients. Otherwise, documented exposures reported by HCWs were related to infected family members (89, 27%), flat mates (42, 13%), or friends/colleagues (35, 11%). Table 2 summarizes the epidemiological findings in our infected employees.

Figure 2 illustrates the chronological order of clusters that were identified among our cohort of infected HCWs. A total of 10 clusters were identified; one with a patient as the index case and was associated with direct patient care, while 9 had a HCW as the index case. The largest cluster was associated with 15 transmissions among HCWs. One cluster was associated with secondary transmission (infection indirectly related to the index case) and involved one HCW. The sources of transmissions in these clusters were found to be related to sharing of accommodation with the index case followed by social gatherings where extended unprotected exposures occurred with the index case in events during food sharing.

Figures 3A and 3B demonstrate the sources of infection among our cohort of infected HCWs. A minority of the infections were confirmed hospital-acquired (1.3%), while possibly hospital-acquired with unknown exposure was observed in 18%, but the majority (80.7%) were community-acquired infections.

Discussion:

The current study includes a sizable number of infected healthcare workers from one hospital during the first wave of the COVID-19 pandemic. Although the study is retrospective, the epidemiological investigations were done in real time given the urgent need to determine the source of each infection in our HCWs to prevent large outbreaks and preserve our working force. In addition, we had the opportunity to follow all infected HCWs for extended periods of time with regards to their persistent symptoms and outcomes.

Our study has several significant findings that need to be highlighted. First, clustering of infections was not infrequent in our cohort of infected HCWs. A total of 10 clusters were identified with the largest involving 15 transmissions, nine had a HCW as the index case, and secondary transmission was identified in one cluster. The majority of clusters were among HCWs living in shared accommodation. Furthermore, and despite of the restrictions on social gatherings in the workplace, such events continued to occur in the accommodations where restrictions were difficult to implement, and this provided fuel to the clusters. The latter highlights the need to do real time epidemiological investigations of all new cases during pandemics; this will serve the purpose of accurate identification of cases early to prevent unidentified transmissions which might lead to larger outbreaks among HCWs with significant impact on their wellbeing and the potential negative impact on the workforce that is essential to maintain during pandemics. Similarly, a frequent but limited number of clustering of infections among HCWs was reported by Ariza-Heredia el al (7) that indicated the occurrence of three clusters involving 2, 4 and 7 HCWs from one cancer hospital. These clustering may represent a type of a super-spreading events; such events were well-described in previous coronaviruses including SARS-CoV-2. (8) (9). The significance of clustering of infection in HCWs calls for special attention in all settings but becomes more challenging in settings where HCWs share accommodation as in our situation. The latter deserves careful planning and mitigation strategies to prevent the loss of the essential HCW forces during pandemics. Several studies from Saudi Arabia reported the increased frequency of COVID-19 among non-Saudi HCWs with coworkers being a common source of spread of infection especially in the setting of hospital-provided accommodations (10) (11) (12). This finding is probably unique to countries with large numbers of expatriate populations working in healthcare settings and surely creates challenges for infection prevention in these settings. Further studies to address this problem are warranted.

Second, the infections in our cohort of young patients with COVID-19 tended to be mild in severity with only 6% requiring hospital admission and 1% requiring ICU admission. None required invasive ventilation and no mortality occurred. Although this is probably related to the younger age among our infected staff, but the effect from early identification and rapid management of more severe infections should not be underestimated. Moreover, the creation of the field hospital with the capability of supporting those with milder infections who required low oxygen supplementation had a dual effect; it relieved the pressure on the acute hospital beds, and it provided those who were not sick enough to be admitted to the hospital access to effective therapies (oxygen and steroids as indicated); the latter probably had also impacted the outcome in a positive way. On the other hand, despite the good outcomes, the burden on the hospital's work force was not simple given that the loss of workdays for each infected HCW was high (average 13 days); the burden was even more significant if we account for staff who were tested but were negative and were given sick-leave days until the test results were made available (data not shown). Asymptomatic infection was documented in 11% of HCWs who were mostly diagnosed as part of contact tracing and testing of those with unprotected exposures. Probably this percentage is less than what has been reported in some studies but in our cohort even mild symptoms were reported and that could have contributed to the smaller percentage of asymptomatic infections. Similar to our findings, Al Maskari et al (13), Mani et al (14), and Wong et al (15) reported no mortality in their cohorts of 204, 185 and 88 infected HCWs with average ages of 36, 40 and 35 years, respectively. An additional study from

Saudi Arabia showed a very low mortality rate of 0.1% among HCWs (12). On the other hand, more severe outcomes were described in large cohorts of infected HCWs; the CDC COVID-19 working group (16) in their study of 9282 infected HCWs, reported higher hospitalization (9.7%), ICU admissions (4.9%) and mortality rates (0.6%) among all age groups included in the study. Zhan et al (4) also reported a mortality rate of 0.6% among 3387 infected HCWs early in the pandemic from China. In a meta-analysis done by Gholami et al (17) that included 28 studies, the overall hospitalization rate was 15.1% and the mortality rate was 1.5% among HCWs infected with the COVID-19 infection. Finally, in another meta-analysis done by Gomez-Ochoa et al (18) that included 97 studies published in 2020, they reported severe complications in 5% and mortality in 0.5% of infected HCWs.

Third, the majority of infections (80%) among HCWs in our cohort were community acquired. The majority of HCWs (48%) did not have any known exposure, but when exposures were reported, they were likely to be related to infected household/flat mates and friends/colleagues. This underscores the importance of community exposures in HCWs during periods of pandemics and community-wide outbreaks. Therefore, measures to control community spread will also have a significant impact on infection prevention in HCWs. Similarly, other studies from Saudi Arabia during the first wave of COVID-19 showed 90.6% and 78% of cases among HCWs to be community acquired in origin (19) (11). In addition, working in wards/units designated for COVID-19 infected patients was not associated with an increased risk of acquiring COVID-19 infection. These studies highlight the importance of community exposures as a source of infection among HCWs, and also indirectly show that adherence to personal protective equipment (PPEs) seemed to be working well in preventing infections among HCWs if supplies were maintained. Nonetheless, designation of dedicated wards and units for COVID-19 infected patients made it easier to provide focused training and allocate resources to these areas. Similarly, Handal et al (20) in a seroprevalence study from Norway found no significant increase in COVID-19 infection in HCWs with high exposure to infected patients versus those with low exposure. On the other hand, Sims et al (21) reported increased seropositivity among HCWs with direct exposure to COVID-19 patients, but when they accounted for wearing PPEs, the rate was significantly reduced in HCWs who wore N95 respirators. In another study by Nioi et al (3) who reported the Italian experience with COVID-19 infections among HCWs, shortages in PPE supplies especially in primary care settings were associated with increased risks of COVID-19 infections and deaths among physicians. Contrary to our results, Robles-Perez et al (22) and Iversen et al (23) conducted 2 large studies in Mexico and Denmark and reported higher infection rates among HCWs caring for COVID-19 infected patients, but the availability of and adherence to wearing PPEs were not reported in both studies since proper use of PPE would be a major determinant of infection in HCWs directly exposed to COVID-19 infected patients. Furthermore, in a study from Saudi Arabia, seroprevalence was higher among HCWs who worked in designated COVID-19 hospitals than non-COVID-19 hospitals (24).

Our study has several limitations inherent to its design. This is a retrospective study with the possibility of having missed or incomplete data that we couldn't account for. Although contact tracing was done for each positive case with additional testing of all individuals who had unprotected exposures, data of negative test results was not stored in a way that can be linked to the individual cases in the clusters to give a complete picture of the extent of testing that was done after each positive case. Moreover, serological testing was not carried out as part of the investigation of cases and clusters; if done, this could have improved the detection of additional cases and probably could have given more accurate estimates of the sizes of clusters. In addition, although the clustering of cases and all possible links were carefully investigated in real time, there may be some links or exposures which were not identified and that could have lead to an inaccurate representation of the clusters.

In summary, clustering of COVID-19 infections among HCWs is common and, in our cohort, was found to be related to shared accommodation and social gatherings. COVID-19 infection in our young cohort of

Admission/isolation location (total number = 416)*:		
Home isolation	116	28%
Admission to the field hospital	146	35%
Isolation in designated accommodation	128	31%
Hospital admission	23	6%
ICU admission	3	1%
Outcome:		
Recovery	205	63%
Persistence of symptoms	121	37%
Cough/other respiratory symptoms	41	13%
Aches/headache	34	10%
Loss of smell/taste	14	4.3%
Fatigue	12	3.7%
Diarrhea/other GI symptoms	6	1.8%
Others	22	6.7%
Death	0	0%
Sick-leave days granted		
10 days	95	29%
11-15 days	182	56%
16-20 days	31	9.5%
21-30 days	15	5%
31-45 days	2	0.6%
60 days	1	0.3%

*Many patients (number = 90) were admitted to different locations during their illnesses.

Table 2. Findings of epidemiological investigations. Total number = 326.

Parameter	Number (percentages*)	P value
Accommodation type		
Private	206/1610	0.01
Shared	120/690	
Clustering of cases		
Isolated case	271 (83%)	---
Cluster-related	55 (17%)	
Type of profession		
HCW with direct patient contact	182 (56%)	---
Supportive services	78 (24%)	
Administrative services	65 (20%)	
Location of work		
COVID-19 dedicated units/wards	52/297	0.13
All other areas	274/2003	
Source of infection		
Patient care related	63 (19%)	---
Others	263 (81%)	
Exposure type:		
A positive family member	89 (27%)	---
A positive flat mate	42 (13%)	
A positive friend or colleague	35 (11%)	
A positive patient	3 (1%)	
No known exposure	157 (48%)	

*Percentages when reported are from the total number of infected HCWs.