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Identifying medical professionals at risk for in-hospital COVID-19 infection: a snapshot during a "tsunami" highlighting unexpected risks

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Abstract: The aim of this study was to profile healthcare professionals (HCPs) who infected with COVID-19 in hospital while working in a COVID-19 hub hospital during the pandemic. A questionnaire was sent to all HCPs from whom nasopharyngeal swabs (NPS) were collected. The type of work, work environment, individual characteristics, and modality of infection were analyzed. Working areas were categorized into COVID-free areas (wards and ICUs for patients without COVID-19, medical offices, and hospitality counters) and COVID+ areas (dedicated wards and the ICU for patients with COVID-19). From March 1 to 20, 2020, 302 HCPs were tested: 251 (83.1%) responded to the questionnaire, but 9 were excluded since infection occurred outside the hospital. The remaining 242 subjects included 53 (21.9%) with positive NPS and 189 (78.1%) with negative NPS, significant differences in NPS results were evident depending on the subject's role (p = 0.028). Pairwise post hoc analysis revealed that surgeons had a significantly increased rate of positive NPS (p = 0.001). Of the 189 subjects with negative NPS, 175 (92.6%) worked in COVID-free areas, and 14 (7.4%) in COVID+ areas. Of the 53 subjects with positive NPS, 44 (83.1%) worked in COVID-free areas and 9 (16.9%) worked in COVID+ areas. Medical offices featuring an open space with adjacent desks were identified as areas of higher risk. An apparent cause of infection could not be identified in 21 (39.6%) subjects with positive NPS. Among a total of 251 subjects, 80 (41.5%) of the 193 subjects with negative NPS and 16 (27.6%) of the 58 subjects with positive NPS had been vaccinated against the common flu. In conclusion, the vast majority of subjects with positive NPS came from COVID-free areas. The source of infection could not be identified in a significant portion of subjects with positive NPS. Personnel need better protection, more testing with NPS needs to be performed, and workplace layouts need to be re-thought. Vaccination against the flu seems to provide some protection.

Keywords: COVID-19, SARS-CoV-2, healthcare personnel, healthcare system

Introduction

Since the COVID-19 outbreak caused by SARS-CoV-2, hospitals have managed a high number of critically ill patients, posing a challenge to healthcare systems worldwide (*1-5*). In Europe, Italy was hit first, the impact has rapidly spread, with Lombardy and Veneto being the two most affected regions. Lombardy suffered from a huge number of patients, overwhelming the healthcare system's capability to provide care, despite being one of the most efficient regions within the Italian National Health Service (NHS). A high incidence of COVID-19 has been reported among healthcare professionals (HCPs), over 10,000 HCPs have been infected and over 150 physicians have died (*6*).

Profiling HCPs in terms of specialty and working areas within the hospital would help to identify risks, readdress the need for protection, better highlight the need for testing, and foreshadow new working environments. With these aims in mind, the current study profiled HCPs who infected with COVID-19 in hospital.

Materials and Methods

Overall design

A survey was conducted at the Humanitas Research Hospital (HRH), which has 750 beds, 31 of which

are dedicated to the intensive care unit (ICU). Among 2,580 HCPs working in this hospital, 540 are physicians (including residents), 200 are surgeons (including residents), 75 are anesthesiologists (including residents), 1,140 are nurses and patient care technicians (PCTs), 70 are radiologic technicians (RTs), and 550 are administrative staff.

During the pandemic, HRH handled 260 patients with COVID-19 (47 in the ICU) and 220 without COVID-19. According to regional government guidelines, nasopharyngeal swabs (NPS) were initially collected only from subjects with symptoms suggestive of COVID-19 or after exposure to individuals confirmed to have COVID-19. After March 12, 2020, medical masks became available to all HCPs, given the increased number of individuals with COVID-19, NPS were collected only from symptomatic HCPs.

From March 1 to 20, 2020, 302 HCPs were tested and surveyed.

Statistical analysis

Data were reported as the number and percentage or the median and interquartile range (IQR) as appropriate. Comparisons were made using the chi-square or Mann-Whitney tests. Pairwise post hoc analysis was performed with Bonferroni correction to identify significant variables. Analysis was performed with the software R (version 3.6.1).

Results

Two hundred and fifty one (83.1%) subjects responded to the questionnaire, including 58 with positive NPS and 193 with negative NPS. Nine subjects were excluded from analysis since they reported that they contacted with a COVID-19 patient occurred outside the hospital. The 242 remaining subjects included 53 (21.9%) with positive NPS and 189 (78.1%) with negative NPS.

Of the 242 remaining subjects, females accounted for 56.6% of the subjects with positive NPS and 73.0% of the subjects with negative NPS. No significant differences between the two groups were evident in terms of age or comorbidities (Table 1). Flu-like symptoms were present in 86.8% of subjects with positive NPS and 52.4% of subjects with negative NPS ($p < 0.001$). Only 3 (5.7%) subjects with positive NPS required hospitalization. None of the subjects with negative NPS developed COVID-19.

The 78 physicians (32.2%) included 52 internists, 22 surgeons, and 4 anesthesiologists. Of the total subjects, 74 (30.6%) were nurses, 21 (8.7%) were PCTs, 5 (2.0%) were RTs, 25 were (10.3%) secretaries at hospitality counters, and 39 (16.1%) performed some other role. Significant differences in NPS results were evident depending on the role of HCPs in the hospital ($p = 0.028$). Of the 53 subjects with positive NPS, most (20 subjects, 37.7%) were physicians (11 (55.0%) of whom were surgeons), followed by nurses (28.3%), PCTs (11.3%), and subjects in another discipline as shown in Table 1.

Working areas were categorized in COVID-free areas (wards and ICUs for patients without COVID-19, medical offices, and hospitality counters) and COVID+ areas (dedicated wards and the ICU for patients with COVID-19). Of the 189 subjects with negative NPS, 175 (92.6%) worked in COVID-free areas and 14 (7.4%) worked in COVID+ areas. Of the 53 subjects with positive NPS, 44 (83.0%) worked in COVID-free areas and just 9 (17.0%) worked in COVID+ areas.

Table 2 shows NPS results cross-referenced with working areas and profession. Pairwise post hoc analysis revealed that surgeons had a significantly increased rate of positive NPS ($p = 0.001$). All 7 internists with positive NPS spent the majority of their time in COVID-free wards and the outpatient clinic. Six (54.5%) of the 11 surgeons with positive NPS did the same, while 5 (45.5%) spent more time or had contact with subjects with COVID-19 in medical offices that largely featured an open space with adjacent desks. The 2 anesthesiologists with positive NPS both worked in a COVID-free area. Nine (60.0%) of the 15 nurses with positive NPS worked in a COVID-free area while 6 (40.0%) worked in COVID+ areas. One PCT with positive NPS worked in a COVID+ area while the remaining 5 (83.3%) worked in COVID-free areas, as did all 6 cleaners and the 4 secretaries at hospitality counters with positive NPS. The one RT with positive NPS was also the only subject to be infected in the COVID+ ICU.

Among the 242 subjects analyzed, 195 declared a contact with a potential source of infection: 89 had contact with a colleague who infected with COVID-19, and 106 had contact with a patient with COVID-19. An apparent cause of infection could not be identified in 47 subjects. Figure 1 details the relations between positive NPS, and potential cause of infection. Among the 53 HCPs with positive NPS, 20 (37.7%) and 12 (22.6%) referred to a patient and a colleague as the cause of infection, respectively, while 21(39.6%) could not identify any apparent cause of infection.

Other factors besides work-related transmission were investigated. Of note, among a total of 251 subjects, 80 (41.5%) of the 193 subjects with negative NPS and 16 (27.6%) of the 58 subjects with positive NPS ($p = 0.151$) had been vaccinated against the common flu (Figure 2A). Three (5.2%) of the subjects with positive NPS were hospitalized, and none of them were vaccinated against the common flu (Figure 2B).

Discussion

Since February 18, 2020 when the infection occurred in Lombardy to April 11, the total number of cases in Italy exceeded 100,000 and there were approximately

Table 1. Characteristics of clinical data from the surveyed HCPs categorized by NPS results

Items	Negative NPS	Positive NPS	*p*
N	189	53	
Female (%)	138 (73.0)	30 (56.6)	0.034
Age (years) (median [IQR])	41.00 [32-48]	41.00 [33-46]	0.722
Symptoms before NPS (%)	99 (52.4)	46 (86.8)	< 0.001
Hospitalization (%)	0 (0.0)	3 (5.7)	0.010
Role of HCP (%)			0.028
Internist	45 (23.8)	7 (13.2)	
Surgeon	11 (5.8)	11 (20.8)	
Anesthesiologist	2 (1.1)	2 (3.8)	
Nurse	59 (31.2)	15 (28.3)	
PCT	15 (7.9)	6 (11.3)	
RT	4 (2.1)	1 (1.9)	
Administrative	21 (11.1)	4 (7.5)	
Other	32 (16.9)	7 (13.2)	
Hospital area (%)			
COVID+ area	14 (7.4)	9 (17.0)	
COVID-free area	175 (92.6)	44 (83.0)	
Smokers (%)	41 (21.7)	8 (15.1)	0.388
Vaccinated against season flu (%)	80 (42.3)	16 (30.2)	0.151
Absence of coronary disease (%)	189 (100.0)	53 (100.0)	NA
Peripheral vascular disease (%)	4 (2.1)	1 (1.9)	1.000
Ictus / TIA (%)	1 (0.5)	0 (0.0)	1.000
Chronic obstructive pulmonary disease (%)	5 (2.6)	0 (0.0)	0.516
Mild hepatitis (%)	1 (0.5)	0 (0.0)	1.000
Diabetes (%)			0.298
Absent or controlled by diet	185 (97.9)	51 (96.2)	
Diabetes without organ damage	2 (1.1)	2 (3.8)	
Diabetes with organ damage	2 (1.1)	0 (0.0)	
Chronic kidney disease (%)	2 (1.1)	0 (0.0)	1.000
Local cancer (%)	1 (0.5)	1 (1.9)	0.915
Leukemia (%)	2 (1.1)	0 (0.0)	1.000
Lymphoma (%)	3 (1.6)	0 (0.0)	0.825
AIDS (%)	2 (1.1)	0 (0.0)	1.000
CCI (median [IQR])	0.00 [0.00, 1.00]	0.00 [0.00, 0.00]	0.394

CCI, Charlson comorbidity index; HCP, healthcare professional; NPS, nasopharyngeal swab; PCT, patient care technicians; RT, radiologic technicians.

Table 2. NPS results by working area and profession

Areas/Discipline	Negative NPS		Positive NPS		*p*	pairwise *p*
	N	%	*N*	%		
COVID-free area						
Internist	45	25.7	7	25.7	0.006	
Surgeon	11	6.3	11	6.3		< 0.001
Anesthesiologist	2	1.1	2	1.1		
Nurse	49	28.0	9	28.0		
PCT	11	6.3	5	6.3		
RT	4	2.3	0	2.3		
Administrative	21	12.0	4	12.0		
Other	32	18.3	6	18.3		
COVID+ area						
Nurse	10	71.4	6	71.4	0.273	
PCT	4	28.6	1	28.6		
RT	0	0	1	0		
Other	0	0	1	0		

NPS, nasopharyngeal swab; PCT, patient care technician; RTs, radiologic technician.

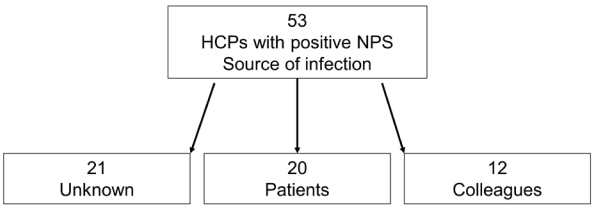

Figure 1. The source of infection for 53 HCPs with positive NPS. HCPs, healthcare professional; NPS, nasopharyngeal swabs.

20,000 total deaths (*7*). These conditions allowed no other option than to look at the problem immediately at hand. Thus, efforts have been focused on supporting COVID-19 wards and the ICU. As the survey results demonstrate, front-line HCPs in contact with patients with COVID-19 have been properly protected. However, the pandemic has been compounded by the global shortage of personal protective equipment (PPE). The WHO at that time was recommending the rational use of PPE in healthcare and home care settings (*8*). Given the scarcity of PPE in the supply chain, its acquisition was chaotically marked by panic buying and stockpiling, as a consequence, the demand for PPE even in hospitals could not be satisfied. This hampered

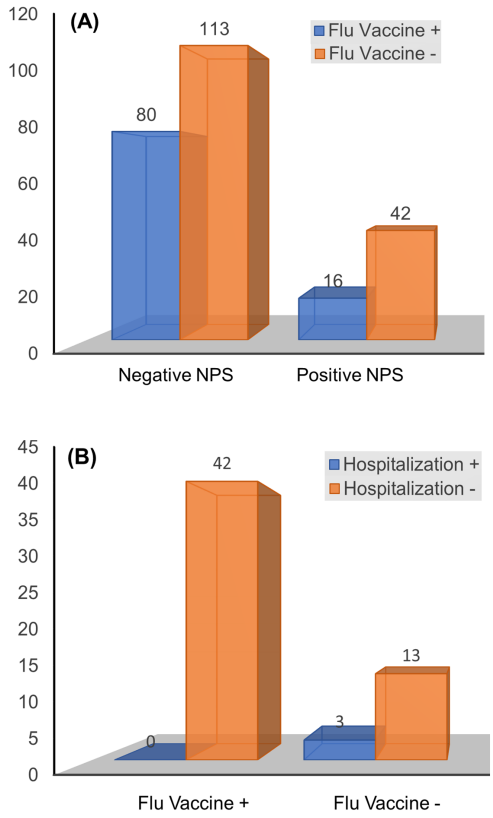

Figure 2. (A) number of patients who had NPS and were vaccinated or not against the common flu; (B) number of patients NPS positive, categorized based on common flu vaccination status who were hospitalized or not. NPS, nasopharyngeal swabs.

the equipping of HCPs with PPE as recommended (*9*).

At this hospital, the situation stabilized on March 12, 2020. Possibly, the lack of PPE is one reason why all but one of the HCPs with positive NPS was working in COVID-free areas. However, the layouts of working areas may have been part of the problem, too. Of note, surgeons represented 9% of the subjects tested but accounted for over 20% of subjects infected with COVID-19 and over 50% of physicians with COVID-19. That occurred during a time frame in which surgical activity decreased significantly to allow the hospital to focus on the outbreak. Therefore, surgeons dedicated more time to research and spent more time in offices featuring an open space with adjacent desks, which inevitably facilitated the transmission of the virus. Given the presumably prolonged duration of this pandemic and the increased incidence of zoonosis accentuated by globalization, the current findings should induce facilities, and especially hospitals, to reconsider the layouts of working areas.

Another issue is limiting testing to symptomatic individuals. The regional government guidelines limited the collection of NPS to symptomatic patients. The lack of tools for testing and concern about the limited value of NPS results may have played a role in prompting that restriction.

Nonetheless, the current survey revealed that 40% of subjects with positive NPS had not been warned about significant contact with asymptomatic carriers. Screening of HCPs, which presumably will benefit from the introduction of and improvements in blood tests (*10*), and other diagnostic tools (*11*), is certain to play a crucial role in the near future once hospitals reassess the need to preemptively isolate areas for patients with COVID-19 from areas for patients without COVID-19. This is particularly relevant because of the need for prompt and appropriate care for patients with other conditions, like cancer, whose treatment was unfortunately delayed during the pandemic (*12*).

A final point worth mentioning is the extent of flu vaccination among the HCPs surveyed. Survey results indicated that vaccination against the common flu seems to provide some protection against COVID-19. The current findings are speculative and require further investigation, but HCPs might be encouraged to be vaccinated against the flu.

The limitations of this study are readily acknowledged. However, this study can help to understand an otherwise unpredictable phenomenon. The pandemic was a kind of "tsunami" where decision-making processes were also influenced by external factors. Nonetheless, results revealed that the profile of HCPs and their working areas were major risks factors for infection. These data could support and enhance preemptive recommendations (*8*).

In conclusion, a healthcare system is obviously placed under significant strain because of a pandemic, and concerns about in-hospital COVID-19 infection could further undermine its ability to address the emergency. Looking toward the future and in light of experiences combatting this pandemic (*13*), the categories of COVID+ and COVID-free areas should be reassessed in the healthcare system. This study has provided data highlighting the need to pay more attention to HCPs working in COVID-free areas. Essential approaches to dealing with that risk are providing adequate PPE, providing working areas that allow social distancing, and implementing more efficient screening policies to identifying asymptomatic individuals.

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