Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Clinical characteristics and humoral immune response in healthcare workers with COVID-19 in a teaching hospital in Belgium

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SUMMARY

Background: Healthcare workers (HCWs) are at high risk of acquiring COVID-19 and could play a role in nosocomial transmission. Since 4th February 2020, Belgian Health authorities reported more than 90,568 cases, of which 8.3% were HCWs. Data on clinical characteristics, sources of infection and humoral immune response of HCWs with COVID-19 remain scarce.
Aim: To analyse the clinical characteristics, humoral immune response, sources of contamination, and outcomes among HCWs with COVID-19.
Methods: This retrospective study included 176 HCWs with laboratory-confirmed COVID-19 in a teaching hospital in Belgium. Between 1st March and 31st May 2020, all HCWs with symptoms suspected of COVID-19 were tested by reverse transcription polymerase chain reaction on a nasopharyngeal swab. Serological testing was performed between 55 and 137 days after the onset of symptoms.
Findings: Median age was 40.8 years and 75% were female. Median delay between onset of symptoms and diagnosis was 4.39 days. Most frequent symptoms were cough and headache (both 75%). Fever accounted for 68.7%. Most represented professions were nurses (42%). HCWs were mainly infected by patient contact (32.9%); 7.6% required hospitalization and 1.7% were admitted to the intensive care unit. Unfortunately, one HCW died (0.5%). Total antibodies were positive in 109/126 (86.5%).
Conclusions: Clinical presentation of COVID-19 in HCWs does not differ from the general population. However, outcomes were more favourable with a mortality rate lower than that reported in Belgian COVID-19 patients in general (16%). The main source of infection was the hospital setting. Our positive antibodies rate was high but lower than previously reported.

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Introduction

In December 2019, a new coronavirus responsible for severe acute respiratory syndrome (SARS-CoV-2) appeared in Wuhan, China [1]. The disease, later named COVID-19, has now spread worldwide. The World Health Organization (WHO) declared a pandemic on 11th March 2020 [2]. Healthcare workers (HCWs) are at increased risk of being exposed to SARS-CoV-2 and could potentially have a role in hospital transmission. Currently, the extent of SARS-CoV-2 transmission and risk factors associated with infection in healthcare settings are unclear. On 5th June 2020, the International Council of Nurses (ICN) showed that, on average, 6% of all confirmed cases of COVID-19 were among HCWs. The figures released by the ICN were based on data from just 30 countries. If that proportion were to be repeated globally, the 3.5 million confirmed cases of COVID-19 around the world would yield a figure of 210,000 for the number of infected HCWs [3]. Bandyopadhyay *et al.* reported that the total number of HCWs deaths as of 8th May 2020 was 1413 [4], representing 0.5% of the 270,426 COVID-19 deaths worldwide. This also suggests that for every 100 HCWs who were infected, one died. At the end of August, more than 800,000 deaths had been recorded worldwide. The first case of SARS-CoV-2 infection in Belgium was reported on 4th February 2020. Since then, the Institute of Public Health in Belgium (Sciensano) has reported over 90,568 cases, of which 8.3% were HCWs [5]. Recently it was estimated that 600 HCWs had been hospitalized in Belgium due to COVID-19 since mid-March [5]. However, data on the clinical characteristics, outcomes, sources of infection, and humoral immune response of HCWs with COVID-19 infection remain scarce. We report here those factors amongst a cohort of 176 HCWs with laboratory-confirmed COVID-19 in a large teaching hospital in Brussels, Belgium.

Materials and methods

This was a retrospective study performed between 1st March and 31st May 2020, in a large teaching hospital (7757 employees), Cliniques Universitaires Saint-Luc (CUSL) in Brussels, Belgium. Ethical approval for this study (Ethical Committee no. CEHF 2020/06AVR/201) was provided by the Institutional Review Board (CEBH of the Université catholique de Louvain (UCLouvain), Brussels, Belgium), that provided a waiver for written informed consent, given the retrospective nature of the study, de-identified and anonymous analysis.

Demographic and clinical characteristics, reverse transcription polymerase chain reaction (RT-PCR) and serological results were recorded using our institutional database (Medical Explorer 5v8) and the laboratory database. A standardized survey (written, sometimes completed with an oral interview) were used to collected other data such as the date of onset of symptoms, working places of the HCW, and plausible sources of contamination.

Testing strategy

All employees of our hospital with symptoms suspected of COVID-19 were screened. Suspect symptoms were defined as fever, cough, shortness of breath or dyspnea, sore throat, rhinorrhoea, headaches, fatigue, myalgia, anosmia, ageusia, diarrhoea or other gastrointestinal symptoms. Two periods of screening were identified. The first was between 1st March and 30th March, when the Belgian Institute of Public Health (Sciensano) recommended screening HCWs if they had fever together with symptoms of COVID-19; the second period was between 1st April and 31st May when it was recommended to screen HCWs if they had symptoms of COVID-19 irrespective of fever. Out of the 7757 hospital employees, 643 (8.3%) were screened. Among these 643 HCWs, 183 tested positive (28.5%) for SARS-CoV-2 by RT-PCR and 176 of them were included in this study (missing data). Some staff members ($N = 23$) were also tested without criteria if they reported close contact with a confirmed SARS-CoV-2-positive person. It is important to note that different measures were taken during that period of testing. The Belgian Government declared a partial lockdown on 13th March (catering sector) which became full on the 18th March (all non-essential shops). Furthermore, masks were made mandatory for every hospital employee and patient from 1st April 2020 in our hospital (also the date when fever ceased to be a screening criterion).

SARS-CoV-2 RNA detection in nasopharyngeal swabs was by the genesig® Real-Time RT-PCR assay (Primerdesign Ltd, Chandler's Ford, UK). This assay, performed on RNA extracts, allows the detection of viral RNA by targeting the RNA-dependent RNA polymerase (RdRp) gene. The amplification was performed on a LightCycle 480 instrument (Roche Diagnostics, Mannheim, Germany) according to the manufacturer's recommendations. A test with a cycle threshold (Ct) under 40 was considered positive.

Sources of contamination

We classified the source of infection as coming from a patient (contact with a SARS-CoV-2 positive patient), a co-worker (SARS-CoV-2 positive) or private (household member or private setting in whom a SARS-CoV-2 positive person was detected).The healthcare setting was then either patient or co-worker contact. To establish the source of infection, we asked HCWs if they thought they had had contact with a patient, co-worker or an individual outside the healthcare setting who had been confirmed COVID-19 positive during the 14 days before onset of symptoms. If there was more than one possible contact we considered that the source was multiple; if there was no history of definite contact the source was deemed unknown. HCWs were considered in three groups: the first was HCWs working in COVID-dedicated wards; the second group was HCWs working in non-COVID wards; the final group was HCWs working in other hospital departments.

Serological testing

Serological testing was performed between 20th June and 30th June 2020 (55 and 137 days after the onset of symptoms on 126/176 HCWS (71.6%) in whom 79.3% (100/126) was performed beyond 90 days. To investigate the humoral immune response, two methods were used. The first was the Roche Elecsys Anti SARS-CoV-2, which is a pan-immunoglobulin test targeting nucleocapsid with a reported sensitivity of 100% and specificity of 95% [6]. We considered a positive antibody response in HCWs as a HCW with positive serology result on the Roche Elecsys Anti SARS-CoV-2. If this test was positive, a second test, the Maglumi™2019-n-Cov, was then performed to identify IgM or IgG antibodies (Snibe Diagnostic, Shenzhen, China). These are fully automated quantitative chemiluminescent immunoassays (CLIA) using magnetic microbeads

Table I
Demographic characteristics, profession, symptoms, exposures, outcome and time between onset of symptoms and diagnosis among healthcare workers with COVID-19

	Healthcare workers, *N* (%)				*P*
	Overall (*N* = 176)	COVID units (*N* = 53)	Non-COVID units (*N* = 81)	Other departments (*N* = 42)	
Woman	132 (75%)	39 (73.6%)	64 (79%)	29 (69%)	0.0009
Age – median	40.8	41.9	40.9	39.2	NS
Profession					<0.001[b]
Physician	29 (16.4%)	10 (18.8%)	19 (23.4%)	0 (0%)	
Nurse[b]	74 (42%)	33 (62.2%)	41 (50.6%)	0 (0%)	
Paramedics	21 (11.9%)	8 (15%)[d]	12 (14.8%)[e]	1 (2.3%)[f]	
Other, no direct patient contact	52 (29.5%)	2 (3.7%)[g]	9 (11.1%)[h]	41 (97.6%)[i]	
Symptoms					
Cough	133 (75.5%)	38 (71.6%)	62 (76.5%)	33 (78.5%)	NS
Headache	132 (75%)	43 (81.1%)	60 (74%)	29 (69%)	NS
ENT symptoms[a]	126 (71.5%)	37 (69.8%)	61 (75.3%)	28 (66.6%)	NS
Fever[c]	121 (68.7%)	39 (73.5%)	57 (70.3%)	25 (59.5%)	NS
Myalgia	115 (65.3%)	38 (71.6%)	52 (64.1%)	25 (59.5%)	NS
Fatigue	93 (52.8%)	32 (60.3%)	43 (53%)	18 (42.8%)	NS
Shortness of breath	66 (37.5%)	18 (33.9%)	34 (41.9%)	14 (33.3%)	NS
Gastrointestinal symptoms[b]	54 (30.6%)	15 (28.3%)	25 (30.8%)	14 (33.3%)	NS
Ageusia or anosmia	40 (22.7%)	13 (24.5%)	19 (23.4%)	8 (19%)	NS
Outcomes					
Hospitalization	13 (7.3%)	4 (7.5%)	6 (7.4%)	3 (7.1%)	NS
ICU	3 (1.7%)	1 (1.8%)	1 (1.2%)	1 (2.3%)	NS
Death	1 (0.5%)	1 (1.8%)	0 (0%)	0 (0%)	NS
Probable source of contamination					
Hospital, health care setting	58 (32.9%)	35 (66%)	22 (27.1%)	1 (2.3%)	*P*<0.0001
Private sphere	47 (26.7%)	10 (18.8%)	25 (30.8%)	12 (28.5%)	NS
Hospital, no health care setting	40 (22.7%)	4 (7.5%)	18 (22.2%)	18 (42.8%)	0.0002
Unknown	23 (13%)	2 (3.7%)	11 (13.5%)	10 (23.8%)	0.0156
Multiple sources	8 (4.5%)	2 (3.7%)	5 (6.1%)	1 (2.3%)	NS
Time between onset of symptoms and diagnosis – median (range)	4.39 (0–18)	4.09 (0–15)	4.29 (1–18)	5.09 (1–17)	NS

NS, non-significant.
[a] ENT symptoms include sore throat, and/or runny nose.
[b] Gastrointestinal symptoms include diarrhoea, and/or nausea, vomiting, abdominal pain.
[c] Fever is defined as a temperature of >38°C or the presence of solemn chills.
[d] Six assistant nurses and two physiotherapists.
[e] One ophthalmologist technician, five assistant nurses, one audiologist, four physiotherapists, and one radiology technologist.
[f] One priest.
[g] One administrative nurse assistant and one cleaner.
[h] Two administrative nurse assistants, two social workers, one dietician, and four psychologists.
[i] Thirteen administrative workers, five administrative nurses, four cleaners, three pharmacists, four childcare workers, seven secretaries, one waitress, one general technician, one social worker, and two laboratory technicians.

coated with SARS-CoV-2 recombinant antigen labelled with ABEI, a non-enzyme small molecule with a special molecular formula that enhances stability in acid and alkaline solutions. The thresholds of positivity for these automated immunoassays are 1.0 AU/mL for IgM and IgG. The sensitivity and specificity are reported to be 64.5% and 100%, respectively [7]. Of note, diagnostic sensitivity is said to increase over time, reaching 95.5% (95% confidence interval (CI) = 84.9–99.2) between 15 and 25 days after symptom onset [7].

Statistical analysis

We collected data on an Excel sheet. We used GraphPad Prism version 8 to performed analysis. Continuous variables were expressed as means with standard deviations and categorical variables were expressed as counts and percentages. Categorical variables were analysed using chi-squared test or Fisher's exact test. Differences between means or medians were compared using unpaired Student's *t*-test or Mann–Whitney U-test, according to the distribution. All tests were two-sided, with significance set at the 0.05 probability level.

Results

A total of 176 HCWs with laboratory-confirmed COVID-19 were included in this study. Table I summarizes their demographic and clinical characteristics. The median age of the HCWs was 40.8 years (24–64) and 75% were female. Median

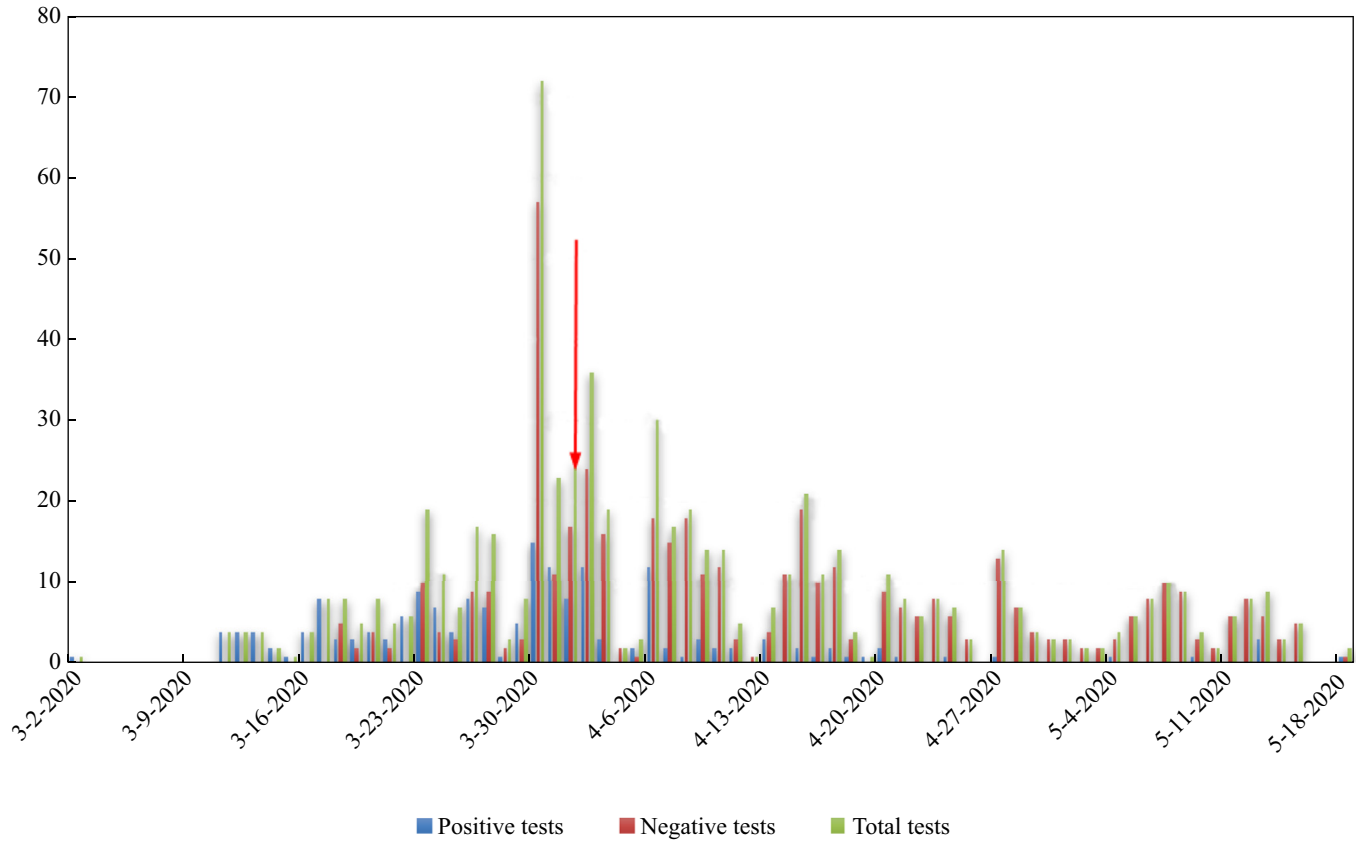

Figure 1. Reverse transcription polymerase chain reaction tests performed on healthcare workers between 1st March and 31st May 2020. 1st March and the days after 18th May are hidden from the graph to ensure a better visibility (no tests were performed on healthcare workers during these periods). Arrow represents the date (4th April) when universal masking was made mandatory inside the hospital.

delay between symptom onset and diagnosis was 4.39 days (range 0—18).

The most frequent symptoms were cough and headache (both 75%), followed by sore throat/rhinorrhoea (71.5%). Fever, myalgia, and fatigue accounted for 68.7%, 65.3% and 52.8%, respectively. Other symptoms were shortness of breath (37.5%), gastrointestinal symptoms, mostly diarrhoea (30.6%), and ageusia/anosmia (22.7%).

Among the 176 cases, 30.1% worked in a COVID-dedicated ward, 46% worked in non-COVID ward and 23.8% in other departments (Table I). The most represented professions were nurses (42%) followed by non-paramedic workers (29.5%); physicians and paramedics accounted for 16.4% and 11.9%, respectively. One priest was considered a paramedic as he had close contact with patients.

A proportion of 32.9% of HCWs were infected through patient contact. Private and co-workers contact accounted for 26.7% and 22.7% of infections, respectively. Multiple sources of contamination were identified in 4.5% of cases, and a source of infection was not identified in 13% of cases. HCWs from COVID-dedicated units were mainly infected by contact with a patient (35/53, 66%) while contamination by a co-worker was the principal source of infection for HCWs from other departments of the hospital (18/42, 42.8%). For the HCWs from non-COVID wards, private contact was most common (30.8%), with infection from patient contact coming second (27.1%). The hospital setting accounted for 55.6% of all sources of infection in all HCWs. HCWs of the COVID unit were at greater risk than others of being infected in healthcare settings ($P<0.001$). No differences were observed between different categories of HCWs concerning infection outside the healthcare setting.

Figure 1 summarizes the timeline of HCW testing by RT-PCR between 1st March and 31st May when 643 tests were performed (460 negative tests and 183 positive tests). Among the 351 tests that were performed between 1st March and 7th April, 199 (56.7%) were negative and 152 (43.3%) positive. The percentages of negative and positive tests were 89.4% (262/293) and 10.6% (31/293), respectively, during the period between 7th April and 31st May. The difference was statistically significant ($P<0.0001$).

The outcomes of the infected HCWs were favourable in most cases. However, 13 (7.3%) required hospitalization; three (1.7%) required intensive care and invasive mechanical ventilation; two patients required extracorporeal oxygenation, and one patient unfortunately died (0.5%) (Table II). The median age of the hospitalized HCWs was 52 years (range 26—64), and 12 (92.3%) had at least one comorbidity.

Total antibodies were positive in 109/126 (86.5%) of HCWs with laboratory confirmed COVID-19. Of the 17/126 (13.5%) who were antibody-negative, 13/17 (76.5%) were tested at more than 3 months, three (17.6 %) between two and three months, and one at less than two months following infection. Conversely, for the 109 total antibodies positive, 87/109 (80%)

Table II
Demographic, clinical characteristics and outcomes of hospitalized healthcare workers with COVID-19

Patient	Age	Sex	Comorbidity	Severity of disease	Treatment	Symptoms at admission	LOS	ICU	Intubation	ECMO	Serology (Roche)	Serology (IgG) (AU/mL)
1	53	F	Asthma	Moderate	HCQ 5 days	Diarrhoea Dry cough Dyspnea Fatigue Fever	10 days	/	/	/	+	/
2	58	F	Hypertension	Severe	HCQ 5 days CS 3 days	Cough Diarrhoea Dyspnea Fatigue Fever Headache Myalgia Rhinorrhea	11 days	/	/	/	+	23.5
3	50	M	Hypercholesterolemia	Critical	HCQ 5 days AZM 3 days High doses of CS	Cough Dyspnea Fatigue Fever Myalgia Rhinorrhea	78 days (60 days in ICU)	Yes	Yes	Yes	+	114.5
4	64	F	Hypertension Type 2 diabetes	Severe	HCQ 5 days AZM 3 days CS 3 days	Anosmia/ageusia Cough Dyspnea Fever Headaches Myalgia Rhinitis	12 days	/	/	/	+	Not done
5	56	F	Type 2 diabetes	Moderate	/	Anosmia/ageusia Cough Dyspnea Fever Headaches Myalgia Vomiting	7 days	/	/	/	+	/
6	47	M	Type 2 diabetes Obesity	Severe	HCQ 5 days AZM 3 days CPAP	Fever Cough Diarrhea Dyspnea Fatigue Rhinorrhea	14 days	/	/	/	+	27.4
7	55	F	None	Moderate	HCQ 5 days		4 days	/	/	/	+	20.9

(*continued on next page*)

Table II (*continued*)

Patient	Age	Sex	Comorbidity	Severity of disease	Treatment	Symptoms at admission	LOS	ICU	Intubation	ECMO	Serology (Roche)	Serology (IgG) (AU/mL)
						Cough Dyspnea Fatigue Fever Headache Rhinorrhea						
8	26	F	Pregnancy (29 weeks) Gestational diabetes	Severe	HCQ 5 days CS 5 days	Cough Dyspnea Fatigue Fever Headache Myalgia	12 days	/	/	/	+	54.3
9	51	F	Chronic neutropenia	Critical	HCQ 5 days CS 5 days	Cough Dyspnea Fatigue Fever Myalgia	15 days (10 days in ICU) Death	Yes	Yes	/	+	4
10	52	F	Chronic kidney disease (KDIGO III	Severe	HCQ 5 days AZM 3 days CS 3 days	Anosmia/ageusia Cough Fever Dyspnea Myalgia	8 days	/	/	/	+	52.4
11	54	M	Hypertension Hypercholesterolemia Obstructive sleep apnea syndrome	Critical	HCQ 5 days AZM 3 days CS 3 days Tocilizumab	Cough Dyspnea Fatigue Fever Headache Myalgia	80 days (62 days in ICU)	Yes	Yes	/	+	64.9
12	57	F	Asthma Hypertension	Moderate	HCQ 5 days	Diarrhoea Dyspnea Fatigue Fever	5 days	/	/	/	+	6.9
13	57	M	Metabolic syndrome	Severe	HCQ 5 days	Cough Dyspnea Fatigue Fever Headache Myalgia Rhinorrhea	9 days	/	/	/	+	/

AZM, azithromycin; CS, Corticosteroids; ECMO, extracorporeal membrane oxygenation; HCQ, hydroxychloroquine; ICU, intensive care unit; LOS, length of stay.

had been tested after 3 months and 22 (20%) between two and three months.

One hundred and two (102/109,93.6%) were IgM-negative and 69/109 (63.3%) were IgG-positive. Of the 69/109 IgG positive HCWs, 51 (74%) were tested beyond three months and 18 (26%) between two and three months. In those with IgG negative (40/109), four (10%) were tested between two and three months and the others (36/40, 90%) beyond three months. Ageusia and or anosmia were the most predictive symptoms for positive antibodies, with. 28/29 HCWs with these symptoms being positive for total antibodies.

Discussion

We describe here the clinical characteristics and humoral immune response, as well as sources of infection and outcomes in a cohort of HCWs with laboratory confirmed COVID-19 in our teaching hospital. The clinical presentation was quite similar to other recent studies [8–10]. The United States Department of Health and Human Services (DHHS) reported a study of 4707 HCWs in whom 78% of the HCWs had cough, 68% fever, 66% myalgia, 65% headache, 50% sore throat/rhinorrhea, 41% shortness of breath, 32% diarrhoea, and 16% loss of ageusia or anosmia [8]. These findings are in line with Chinese (110 HCWs) and Dutch (86 HCWs) studies [9,10]. Symptoms in HCWs do not differ with those seen in the general population; according to a meta-analysis by Hu *et al.*, fever, cough, fatigue, dyspnea were present in 85.6%, 65.7%, 42.4%, and 21.4 %, respectively [11]. In our series sore throat/rhinorrhea and headache was more common than in others series (71% and 75%, respectively).

Regarding the source of infection, HCWs in our study were mainly infected through patient contact (32.9%). Private and co-worker contact accounted for 26.7% and 22.7%, respectively. Overall, 55.6% of infections were attributed to contact in healthcare settings, and HCWs working in a COVID unit were at greater risk ($P<0.0001$). Likewise, Burrer *et al.* [8] found that exposure in a healthcare setting accounted for 55% of the cases, household setting 27%, community setting 13% and multiple exposure settings 5%. Lai *et al.* [9] in a study of 110 Chinese HCWs with COVID-19 reported that 65 (59.1%) infections were attributed to contact with patients, 12 (10.9%) to contact with colleagues, and 14 (12.7%) to contact with family or friends.

In our study HCWs from a COVID-dedicated ward were mainly infected by patient contact (66%) while contamination by a co-worker was the principal source of infection for HCWs from other departments of the hospital (42.8%). For the HCWs from non-COVID wards, private sphere seems to be the first source of contamination (30.8%), with contamination by patient contact coming second (27.1%). In a recent meta-analysis [12], data on the specialty of HCWs and the area of the hospital where they were exposed were not available in most of the studies. Only Wang *et al.* [13] had reported that among the affected HCWs, 77.5% worked on general wards, 17.5% in the emergency department and 5% in the intensive care unit. It is important to note that some HCWs worked in both COVID-dedicated wards and non-COVID wards. Indeed, McMichael *et al.* [14] described the incidence of COVID-19 among HCWs working in long-term care facilities, and showed that the temporal and geographical transmission of the disease was in part due to the movement of HCWs from one facility to another.

The outcome of COVID-19 was good, as many of the HCWs presented with mild disease. Thirteen of 176 patients required hospitalization (7.4%) of whom six had severe, and three critical, illness. The median age of hospitalized HCWs was 12 years higher than those who were not hospitalized, and all but one had comorbidities. The mortality in our cohort was lower than reported in COVID-19 patients in general in Belgium (16%) [5]. Sahu *et al.* [12] analysed the incidence of severe or critical disease and deaths among the affected HCWs. The incidence of severe or critical disease was nearly three times lower compared with all positive COVID-19 patients (9.9% vs 29.4%), and the mortality among HCWs was seven times lower (0.3% vs 2.3%). These observations may be explained by the younger age of HCWs, who are also less likely to have comorbidities [14]. Indeed, the median age of HCWs with COVID-19 was 52 years compared with 71 years in all COVID-19 hospitalized patients in Belgium [5]. A US study showed only 6% of HCWs were aged >65 years but 37% of the deaths occurred among this age group [8]. The one HCW who died in our series was aged of 51 years and had chronic neutropenia.

Concerning humoral immune response, total antibodies were positive in 109/126 (86.5%) of HCWs and of the 109 total antibodies positive, 69/109 (63.3 %) were IgG positive. A large study in Spain [15] reported a seroprevalence close to 90% after 14 days after a positive PCR test, which is consistent with a recent study concluding that SARS-CoV-2 IgG antibodies are detected in more than 90% of infected people two weeks after symptom onset [16] and the recently reported 99% of antibody response among confirmed COVID-19 cases [17]. Our results seem to be lower than those reported by other authors [15–17]. This can be partially explained by the fact that we performed serological testing for the majority of the time more than three months after the onset of symptoms (80%). Indeed, rapid decrease of anti-SARS-CoV-2 antibodies in persons with mild COVID-19 have been described [18,19]. Long *et al.* found that the IgG levels in 93.3% (28/30) of the asymptomatic patients and 96.8% (30/31) of the symptomatic patients declined during the early convalescent phase. The median percentage of decrease was 71.1% (range, 32.8–88.8%) for IgG levels in the asymptomatic patients, whereas the median percentage of decrease was 76.2% (range, 10.9–96.2%) in the symptomatic patients [19]. Another explanation could be related to the performance of the assays used for serological testing [18]. Soleimani *et al.* reported the performances of a fully automated chemiluminescent immunoassay (CLIA) on 276 serum samples using the MAGLUMI 800 platform. All COVID-19-free samples had Ab levels below the cut-off values. Hence, the diagnostic specificity was estimated at 100% (95% CI = 96.3–100.0; positive predictive value = 100%). By the 18th day from the onset of symptoms, they reached an optimal diagnostic sensitivity (more than 95.0%) In fact, the diagnostic sensitivity increased over time and between 15 and 25 days after symptoms onset, reached 95.5% (95% CI = 84.9–99.2) [7]. However a recent study of humoral immune response to SARS-CoV-2 in Iceland by Gudbjartsson *et al.* using two pan-immunoglobulin (pan-Ig) assays found that over 1797 persons who had recovered from SARS-CoV-2 infection, 1107 of the 1215 who were tested (91.1%) were seropositive and antiviral

antibody titers increased during 2 months after diagnosis by quantitative PCR and remained on a plateau for 4 months [20].

This study has several limitations. First, it is a retrospective single-centre study, albeit conducted in a large teaching hospital with over 7000 employees. Second, testing and surveys were based on self-reported symptoms, which could have led to an over-reporting of specific symptoms. Third, there is a lack of knowledge of the underlying health conditions of all HCWs. Another limitation is that it was not possible to follow the kinetics of antibodies as levels were measured at a single time-point. Finally, we do not know the total number of employees who worked in the dedicated or non-dedicated COVID wards, which prevented us establishing the actual rates of infection amongst HCWs working in different types of ward. The source of infection was determined on the basis of self-reported data by HCWs, which may not have been accurate; in particular HCWs working in dedicated COVID wards may have over-estimated the likelihood that they acquired their infection from patients.

Despite these limitations, we provide here an excellent and relatively complete point of view of HCWs with laboratory-confirmed COVID-19.

In conclusion, the clinical presentation of COVID-19 in HCWs does not differ from the general population. However, outcomes were more favourable with a mortality rate (1.7%) lower than that reported in Belgian COVID-19 patients in general (16%). This can be explained by the younger age of HCWs who probably also have fewer comorbidities. The main source of infection was in healthcare settings (55.6%). This underlines the importance of having clear protective procedures and also the fact of giving personal protective equipment of quality to HCWs. Our positive antibodies rate was high, but lower than in some other reports. Whether antibodies in HCWs confer protection against reinfection remains unclear [20].

Conflict of interest statement

All authors report no conflicts of interest relevant to this article.

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