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Underascertainment of COVID-19 cases among first responders: a seroepidemiological study

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Background	Providing frontline support places first responders at a high risk for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection.
Aims	This study was aimed to determine the anti-SARS-CoV-2 seroprevalence in a cohort of first responders (i.e. firefighters/paramedics), to detect the underascertainment rate and to assess risk factors associated with seropositivity.
Methods	We conducted a serological survey among 745 first responders in Germany during 27 November and 4 December 2020 to determine the anti-SARS-CoV-2 seroprevalence using Elecsys® Anti-SARS-CoV-2 immunoassay (Roche Diagnostics, Mannheim, Germany). As part of the examination, participants were asked to provide information on coronavirus disease 2019 (COVID-19)-like-symptoms, information on sociodemographic characteristics and workplace risk factors for a SARS-CoV-2 infection and any prior COVID-19 infection. Descriptive statistics and logistic regression analysis were performed and seroprevalence estimates were adjusted for test sensitivity and specificity.
Results	The test-adjusted seroprevalence was 4% (95% CI 3.1–6.2) and the underascertainment rate was 2.3. Of those tested SARS-CoV-2 antibody positive, 41% were aware that they had been infected in the past. Seropositivity was elevated among paramedics who worked in the emergency rescue team providing first level of pre-hospital emergency care (6% [95% CI 3.4–8.6]) and those directly exposed to a COVID-19 case (5% [95% CI 3.5–8.1]). Overall, the seroprevalence and the underascertainment rate were higher among first responders than among the general population.
Conclusions	The high seroprevalence and underascertainment rate highlight the need to mitigate potential transmission within and between first responders and patients. Workplace control measures such as increased and regular COVID-19-testing and the prompt vaccination of all personnel are necessary.
Key words	COVID-19; firefighters; infection risk; occupational medicine; paramedics; SARS-CoV-2; seroprevalence.

Introduction

Frontline healthcare workers, such as first responders (i.e., firefighters/paramedics), are an integral part of the response to coronavirus disease 2019 (COVID-19) and are at increased risk of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection [1]. Investigating the role of the workplace is of great importance, given that the variety of work tasks that may contribute to the spread of infection between staff and patients [1]. Currently, relatively little information is available about the seroprevalence and underascertainment of COVID-19 infection among first responders [2]. Understanding occupational risks for a SARS-CoV-2 infection and grasping the extend of undetected infections among first responders are vital for designing appropriate occupational safety and health measures and to protect both patients and first responders from an

Key learning points

What is already known about this subject:

- First responders, including firefighters and paramedics, are at high risk of SARS-CoV-2 infection risk due to their daily work with patients.
- Currently, only a limited amount of evidence on the level of SARS-CoV-2 infection and the rate of undetected COVID-19 cases among first responders is available.

What this study adds:

- We present an estimate for the SARS-CoV-2 seroprevalence, underascertainment rate and its determinants among first responders from Germany during the second pandemic wave.
- Given that around 60% of employees did not know that they had COVID-19 in the past, the results stress the need for increased COVID-19 monitoring and testing.

What impact this may have on practice or policy:

- The high underascertainment of COVID-19 cases among first responders underscore the importance of expanding and continuous COVID-19 testing.
- The results highlight the need for a comprehensive occupational risk assessment, which may ultimately help make informed decisions about crucial occupational safety and health measures.

infection [3,4]. This study aimed to: (i) determine the anti-SARS-CoV-2 seroprevalence, (ii) detect the rate of undetected infections and (iii) assess risk factors associated with seropositivity in a cohort of first responders.

Methods

This seroprevalence study was conducted between 27 November and 4 December 2020 in Düsseldorf (Germany) and the entire personnel from the fire department of Düsseldorf was invited to participate. The fire department consists of the following working groups: (i) firefighters, (ii) paramedics of the emergency rescue team (i.e. emergency pre-hospital medical services), (iii) paramedics of the patient transport team (i.e. transfers of patients to and from medical facilities in non-emergency situations) and (iv) technicians/administrative officials. Work tasks often overlap and depend on the shift.

Volunteering and consenting participants completed a self-administered questionnaire to capture epidemiological data (e.g. sociodemographic characteristics, workplace risk factors). Blood samples were tested for SARS-CoV-2 antibodies using the Roche Cobas Elecsys® panIg-anti-SARS-CoV-2 immunoassay (Roche Diagnostics, Mannheim, Germany), with a clinical specificity of 99.8% and sensitivity of 99.5%. A cut off index (COI) was used to classify results of as negative (COI < 1) or positive (COI ≥ 1.0) for circulating anti-SARS CoV-2 antibodies. Positive panIg-anti-SARS-CoV-2 serum samples were subject to SARS-CoV-2 neutralization assay.

To examine the main outcome of testing anti-SARS-CoV-2 seropositive by sociodemographic characteristics and workplace risk factors, descriptive statistics and adjusted as well as unadjusted binary logistic regression models were conducted. The underascertainment of SARS-CoV-2 infections was calculated as the ratio of two population proportions: the proportion of SARS-CoV-2 infections calculated from our study and the registered cumulative incidence of non-fatal reverse transcriptase-polymerase chain reaction (RT-PCR)-positive cases in employees of the fire department. A detailed description of the methodology is provided in Supplemental Material. The study was approved by the Medical Faculty of the Heinrich Heine University.

Results

A total of 745 first responders participated in the study, equalling a response rate of 63% (Figure S1, available as Supplementary data at *Occupational Medicine* Online). Of those, 34 (4% ([95% CI 3.1–6.2]) participants were seropositive. Only 14 (41%) participants reported previous positive results for SARS-CoV-2 by RT-PCR and the underascertainment was 2.3 (Table 1; Table S1, available as Supplementary data at *Occupational Medicine* Online). Neutralizing antibodies were detected in 26 individuals (77%) (Table 1).

Seroprevalence was elevated among paramedics working in the emergency rescue team (6% [95% CI 3.4–8.6]), with direct exposure to patients (5% [95% CI 3.5–8.1]), direct contact to a COVID-19 case with a distance of less than 1.5 m (9% [95% CI 5.8–13.2]) and in younger employees (18–39 years: 5% [95% CI 3.5–8.3]). Seroprevalence was significantly associated with working as a paramedic in the emergency rescue team (odds ratio [OR]: 2.5, 95% CI 1.0–6.3]) and with direct contact to a COVID-19 case (OR: 7.3, 95% CI 4.3–12.4) (Table 2).

Table 1. Comparison of different prevalence measures of SARS CoV-2 antibodies (unadjusted)

Population		Positive SARS-CoV-2 PCR prior to study[a]	Anti-SARS CoV-2 seroprevalence (unadjusted)	Participants with neutralizing antibodies titters[b]
Employees of the fire department Total = 745	Total of the sample % [95% CI]	3% [1.7–4.1]	5% [3.3–6.3]	4% [2.4–5.1]
	Total	20	34	26
	Number of those with positive by PCR prior to study (%[c])	–	14 (41%)	11 (42%)
	Number of those who are seropositive (%[c])	14 (70%)	–	[b]
	Number of those with neutralizing antibody titters (%[c])	11 (55%)	26 (76%)	–

[a]Self-reported SARS-CoV-2 infection (positive by RT-PCR) since February 2020.
[b]Only in case of a positive Roche Cobas Elecsys® Anti-SARS-CoV-2 test, neutralizing antibody titter assay was performed.
[c]Column percentages related to the total number with positive PCR or search or neutralization test.

Due to the small sample size (n = 20), only limited conclusions can be drawn about the risk factors for first responders who are seropositive but did not have a positive SARS-CoV-2 RT-PCR test in the past. Tendencies for a higher probability of an undetected infection were found for men (2% [95% CI 1.0–3.9]) and for those living alone (6% [95% CI 2.8–11.8]) (Table 2).

Discussion

First responders (4%) had a significantly higher seroprevalence than the general German population (1%) and only 41% were aware that they had COVID-19 in the past [5]. Our findings corroborate previous findings by determining a higher seroprevalence among first responders of the emergency rescue team, with contact to a COVID-19 case and younger employees [6,7]. The elevated seroprevalence in younger employees may be explained by younger employees being more likely to work in the emergency rescue team and more frequently exposed to someone with COVID-19. Considering the relatively low number of participants with neutralizing antibodies, it is possible that most infections occurred early during the pandemic, i.e. at a time when modes of SARS-CoV-2 virus transmission and contagiousness were unclear [8]. Additionally, the high underascertainment is likely due to a combination of symptom-based testing, asymptomatic and light symptomatic infections and not consulting a doctor [9]. At the beginning of the pandemic in Germany, SARS-CoV-2 testing was primarily symptom-based and not obligatory for healthcare personnel. Although this remains speculative, it is possible that presenteeism (i.e. working while sick) may contribute to the transmission a disease, especially given that healthcare personnel is more inclined to presenteeism than other professional groups due to their enhanced sense of responsibility for the wellbeing of others [10]. This sense of responsibility maybe intensified during a public health emergency such as the COVID-19 pandemic.

The study has limitations. First, the cross-sectional study design does not allow drawing conclusion about causal relationship between the source and time of infection. Therefore, we cannot rule out the possibility of other infection sources in leisure time outside the worksite. Second, non-participation may have biased our results. However, the response rate was high (63%) and there are no indications of systematic bias due to selective non-participation. In fact, the main reason for non-participation is the short survey period, and consequently persons on vacation or sick leave not being able to participate. However, sickness absence in this population is primarily due to musculoskeletal disorders and mental illnesses, for which an association with the risk of infection is unlikely.

To conclude, our study highlights the importance of COVID-19-related occupational safety and health measures. The extension of regular SARS-CoV-2 testing and surveillance is necessary in first responders.

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Table 2. Prevalence of SARS-CoV-2 antibodies in first responders and association with seropositivity

	Total number of participants	Rate of seropositive participants	OR for being seropositive unadjusted	AOR[a] for being seropositive	Total number of participants without prior self-reported SARS-CoV-2 infection (positive by PCR)[b]	Distribution among seropositive participants, but without prior self-reported SARS-CoV-2 infection (positive by PCR)[b]
	n (column-%)	*n* (row-%[c]) [95% CI]	OR [95% CI]	AOR [95% CI]	*n* (column-%)	*n* (row-%[c]) [95% CI]
Total	745 (100)	34 (4) [3.1–6.2]			723 (100)	20 (3) [1.6–4.1]
Sex						
Male	682 (92)	33 (5) [3.3–6.6]	Ref.[d]	Ref.	660 (91)	19 (2) [1.0–3.9]
Female	62 (8)	1 (1) [0.1–8.4]	0.29 [0.0–2.9]	0.22 [0.0–2.2]	62 (9)	1 (2) [1.0–8.7]
Missing	1 (0)	–	–	–	1 (0)	0 (0)
Age group						
18–39 years	375 (51)	21 (5) [3.5–8.3]	Ref.	Ref.	361 (40)	12 (3) [1.7–5.6]
40 years and older	355 (49)	12 (3) [1.7–5.6]	0.57 [0.3–1.2]	0.53 [0.3–1.2]	347 (47)	7 (2) [0.8–3.9]
Missing	15 (2)	1 (7) [0.1–29.8]	–	–	15 (3)	1 (7) [0.1–29.8]
Household size						
One person	120 (16)	9 (7) [3.8–13.5]	Ref.	Ref.	116 (16)	7 (6) [2.8–11.8]
Two persons	254 (34)	10 (4) [2.0–6.9]	0.49 [0.2–1.3]	0.54 [0.2–1.4]	246 (34)	3 (1) [3.2–11.4]
Three or more persons	369 (450)	15 (4) [2.3–6.4]	0.51 [0.2–1.2]	0.52 [0.2–1.3]	359 (50)	10 (3) [1.3–4.9]
Missing	2 (0)	–	–	–	2 (0)	0 (0)
Level of education						
Lower/middle	383 (51)	16 (4) [2.6–6.8]	Ref.	Ref.	369 (51)	7 (2) [0.7–3.7]
Higher	348 (47)	18 (5) [2.9–7.5]	1.02 (0.5–2.0)	0.86 [0.4–1.8]	340 (47)	13 (4) [2.1–6.3]
Other/still a student	9 (1)	0 (0)	–	–	9 (1)	0 (0)
Missing	5 (1)	0 (0)	–	–	5 (1)	0 (0)
Work task[e]						
Firefighters	540 (78)	26 (5) [3.1–6.8]	1.97 [0.6–6.2]	1.80 [0.5–3.9]	525 (73)	14 (3) [1.4–4.3]
Paramedics: emergency rescue	400 (60)	24 (6) [3.4–8.6]	2.52 [1.0–6.3]	2.45 [0.8–7.5]	386 (53)	14 (3) [1.9–5.8]
Paramedics: patient transport	162 (24)	9 (5) [2.8–10.1]	1.52 [0.6–3.5]	1.39 [0.6–3.3]	158 (22)	7 (4) [2.0–8.7]
Technicians administrative official	108 (17)	2 (2) [0.3–6.3]	0.35 [0.1–1.8]	0.44 [0.1–2.3]	107 (15)	2 (2) [0.3–6.3]
Chronic condition						
No	620 (83)	29 (5) [3.1–6.5]	Ref.	Ref.	605 (84)	18 (3) [1.7–4.5]
Yes	121 (16)	5 (4) [1.6–9.2]	0.87 [0.3–2.4]	1.22 [0.4–3.5]	115 (16)	2 (2) [0.3–6.0]
Missing		0 (0)	–	–	3 (0)	–
PCR test since February 2020						
Yes	260 (35)	20 (8) [4.9–11.5]	Ref.	Ref.	240 (33)	6 (2) [1.0–5.2]
No, no test needed	394 (53)	12 (3) [1.6–5.1]	0.36 [0.2–0.8]	0.35 [0.2–0.8]	394 (55)	12 (3) [1.6–5.1]

Table 2. Continued

	Total number of participants	Rate of seropositive participants	OR for being seropositive unadjusted	AOR[a] for being seropositive	Total number of participants without prior self-reported SARS-CoV-2 infection (positive by PCR)[b]	Distribution among seropositive participants, but without prior self-reported SARS-CoV-2 infection (positive by PCR)[b]
	n (column-%)	*n* (row-%[c]) [95% CI]	OR [95% CI]	AOR [95% CI]	*n* (column-%)	*n* (row-%[c]) [95% CI]
No, but I thought about getting tested and I asked for one, but did not get one	89 (12)	2 (2) [0.4–7.7]	0.26 [0.0–1.5]	0.27 [0.0–1.3]	89 (12)	2 (2) [0.4–7.7]
Missing	2 (0)	0 (0)	–	–	0 (0)	0 (0)
Self-reported COVID-19						
Negative	236 (32)	6 (2) [1.0–5.3]	Ref.	Ref.	–	–
Positive	20 (3)	14 (70) [48.2–85.8]	21.73 [6.7–68.7]	18.54 [6.0–57.6]	–	–
I don't know	3 (0)	0 (0)	–	–	–	–
Symptoms since February 2020[f]						
Fever ≥38°C	80 (11)	6 (7) [3.3–15.3]	1.86 [0.9–4.8]	1.78 [0.7–4.6]	77 (11)	4 (5) [1.8–12.5]
Cough	222 (30)	16 (7) [4.3–11.3]	2.23 [1.1–4.6]	2.27 [1.1–4.8]	212 (30)	8 (4) [1.7–7.1]
Pneumonia	6 (1)	1 (17) [0.7–56.5]	4.39 [0.5–39.7]	4.29 [0.5–39.1]	5 (1)	0 (0)
Dyspnea or shortness of breath	32 (4)	6 (19) [8.7–35.4]	5.85 [2.2–15.6]	7.67 [2.7–20.4]	25 (4)	0 (0)
Pain when breathing	21 (3)	1 (5) [0.0–22.6]	1.04 [0.1–8.7]	1.02 [0.1–8.5]	20 (3)	0 (0)
Congested nose	283 (38)	20 (7) [4.4–10.5]	2.50 [1.2–5.2]	2.58 [1.2–5.5]	274 (38)	12 (4) [2.3–7.3]
Sore throat	255 (35)	16 (6) [4.2–11.1]	1.78 [0.9–3.6]	1.77 [0.8–3.7]	244 (34)	8 (3) [1.5–6.2]
Loss of smell	23 (3)	12 (52) [33.0–71.1]	36.9 [14.4–94.6]	45.6 [16.4–127.3]	11 (2)	1 (9) [0.3–37.8]
Loss of taste	18 (2)	8 (45) [24.5–66.5]	22.7 [8.1–63.3]	24.1 [8.3–69.8]	10 (1)	1 (10) [0.3–40.5]
No symptoms	252 (34)	2 (1) [0.0–2.7]	0.09 [0.0–0.6]	0.03 [0.0–1.9]	248 (34)	1 (0) [0.0–2.1]
Contact to a confirmed COVID-19 case						
No	387 (52)	9 (2) [1.0–4.2]	Ref.	Ref.	384 (53)	8 (2) [0.9–3.9]
Yes, with a distance ≥1.5m	121 (16)	3 (2) [0.7–6.9]	1.85 [0.7–4.8]	1.84 [0.7–4.7]	119 (17)	2 (2) [0.3–5.8]
Yes, with a distance <1.5m	234 (31)	21 (9) [5.8–13.2]	7.3 [4.3–12.4]	7.5 [4.3–12.8]	219 (30)	10 (4) [2.3–8.1]
Missing	3 (0)	1 (33) [1.5–75.6]	–	–	1 (0.1)	0 (0)
Other exposure						
Working with patients	398 (54)	22 (5) [3.5–8.1]	1.66 [0.8–3.5]	1.51 [0.7–3.8]	382 (53)	12 (3) [1.6–5.2]
Working with customers	123 (17)	3 (2) [0.6–6.8]	1.28 [0.7–2.4]	1.36 [0.8–2.4]	109 (15)	1 (1) [−0.2 to 4.4]

Table 2. Continued

	Total number of participants	Rate of seropositive participants	OR for being seropositive unadjusted	AOR[a] for being seropositive	Total number of participants without prior self-reported SARS-CoV-2 infection (positive by PCR)[b]	Distribution among seropositive participants, but without prior self-reported SARS-CoV-2 infection (positive by PCR)[b]
	n (column-%)	*n* (row-%[c]) [95% CI]	OR [95% CI]	AOR [95% CI]	*n* (column-%)	*n* (row-%[c]) [95% CI]
Attended an event with ≥50 persons	253 (34)	16 (6) [3.8–9.9]	1.78 [0.9–3.7]	1.65 [0.8–3.5]	246 (34)	10 (4) [2.0–7.2]
Travelled outside the EU	43 (6)	2 (5) [1.1–15.4]	1.01 [0.2–4.7]	0.95 [0.2–4.3]	41 (6)	0 (0)
Travelled within the EU	268 (36)	15 (5) [3.2–8.9]	1.44 [0.7–3.0]	1.59 [0.8–3.3]	258 (36)	7 (3) [1.1–5.3]
Adherence to public health measures						
Adheres completely	438 (59)	22 (5) [3.2–7.3]	Ref.	Ref.	420 (58)	10 (2) [1.1–4.2]
Adheres partly	300 (40)	11 (4) [1.9–6.3]	1.85 [0.7–4.8]	1.84 [0.7–4.7]	297 (41)	9 (3) [1.4–5.5]
Missing	7 (1)	1 (14) [0.5–51.5]	7.31 [4.3–12.4]	7.52 [4.3–12.8]	6 (1)	1 (17) [0.7–56.5]

[a]AOR = adjusted odds ratio for age and sex.
[b]For the analysis of subjects with antibodies but without self-reported SARS-CoV-2 infection, all subjects with positive PCR test (*n* = 20) or unknown PCR result (*n* = 2) were excluded. Therefore, the sample size for this group was 723 individuals.
[c]This is the test-adjusted seroprevalence.
[d]ref = reference group.
[e]One person could work in more than one field.
[f]Multiple choices possible.

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Competing interests

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