

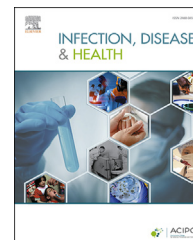


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Research paper

# SARS-CoV-2 seroprevalence in healthcare workers in a tertiary healthcare network in Victoria, Australia

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## KEYWORDS

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**Abstract** *Background:* Healthcare workers (HCW) are exposed to an increased risk of COVID-19 through direct contact with patients and patient environments. We calculated the; seroprevalence of SARS-CoV-2 in HCW at Eastern Health, a tertiary healthcare network in Victoria, and assessed associations with demographics, work location and role.

*Methods:* A cross-sectional cohort study of HCW at Eastern Health was conducted. Serum was analysed for the presence of antibodies to SARS-CoV-2, and all participants completed; an on-line survey collecting information on demographics, place of work, role, and exposures; to COVID-19. Seroprevalence was calculated as the proportion participants with SARS-CoV-2; antibodies out of all tested individuals.

*Results:* The crude seroprevalence of SARS-CoV-2 antibodies in this study was 2.17% (16/736). Thirteen of the 16 (81.2%) positive cases had previously been diagnosed with COVID-19 by PCR: the seroprevalence in the group not previously diagnosed with COVID by PCR was 0.42% (3/720). Having direct contact with COVID-19 patients did not increase the likelihood of having positive serology. A prior history of symptoms consistent with COVID-19 was associated with a higher likelihood of having positive serology (OR 17.2,  $p = 0.006$ , 95%CI: 2.25–131.55).

*Conclusion:* Our calculated seroprevalence of 2.17% is higher than estimated in the general Australian population, but lower than that reported in HCW internationally. The; majority of those with positive serology in our study had previously been diagnosed with COVID-19 by PCR based testing. Seropositivity was not associated with interaction with COVID-19 positive patients, highlighting effective infection prevention and control practices within the workplace.

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### Highlights

- Healthcare workers are exposed to increased risk of infection through direct contact with patients and patient environments.
  - The SARS-CoV-2 seroprevalence in HCW at Eastern Health was 2.17%, higher than estimated in the general community.
  - The majority with positive serology had been diagnosed previously with COVID-19.
  - SARS-CoV-2 seroprevalence in our healthcare network was lower than worldwide estimates in healthcare workers.
  - Our work highlights the low infection rates in Australia, and the importance of preventing healthcare worker infections.
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## Introduction

The Australian experience with COVID-19 is notable for relatively low case numbers compared to many other countries. Daily new infections peaked at 746 on the 20th July 2020 [1] in a second wave of infections. As of the 17th February 2021, 4170 of Victoria's Health care workers (HCW) have been infected with SARS-CoV-2, with up to 73% of infections thought to be acquired in the workplace [2].

Eastern Health (EH) is a tertiary public health network in Melbourne, comprising three acute hospitals and four subacute health centres, servicing a catchment population of >800,000. Since March 2020, EH has provided inpatient care for over 150 patients infected with SARS-CoV-2. In addition, staff were seconded to manage unwell residents at aged care facilities, where a disproportionately high number of cases were diagnosed, significantly contributing to COVID-19 mortality in Australia [3]. As of January 2021, there had been 61 known infections in EH staff members (diagnosed by SARS-CoV-2 PCR) and 371 HCW have been required to undertake a 14-day period of furlough and self-isolation, after identification as a close contact of a positive case.

One in 17 people working in Australia is a registered healthcare practitioner [4], and this does not include workers within healthcare settings such as support, security, cleaning, maintenance and catering staff. HCWs may be at an increased risk of infection due to direct contact with patients and patient environments, and increased frequency of contact with other colleagues in the 'high risk' hospital setting. Infections in HCW may be more likely to be diagnosed due to different case definitions and testing criteria, including asymptomatic screening practices. A recent meta-analysis estimated overall worldwide SARS-CoV-2 seroprevalence at 3.38% (95%CI 3.05–3.72%) [5], noting significant variation with socio-demographic and geographical factors. Another meta-analysis calculated seroprevalence among HCW worldwide at 8.7% (95% confidence interval 6.7–10.9%) [6], indicating a greater risk of infection for HCW compared to the general population.

The impact of staff infections at a workplace as well as at an individual level is significant and warrants closer investigation. We conducted a study to determine the prevalence of SARS-CoV-2 antibodies in HCW at Eastern Health, and associations with demographics, work location and role, and exposure to positive cases.

## Methods

A cross-sectional cohort study of HCW at Eastern Health was performed between the 9th November and 4th December 2020. Ethics was approved by the Eastern Health Human Research Ethics Committee (approval no. LR20/096).

Healthcare workers were invited to participate in the study via departmental emails, posters in clinical areas and messaging on the intranet. We defined HCW as any employee within EH, including subcontracted services such as cleaning and catering. Informed consent was embedded into an online survey which required an electronic signature. We estimated that we would need a sample size of 768 to detect a difference of 2% between seroprevalence of high risk workers vs low risk workers with a power of 0.8, alpha of 0.05 and beta of 0.2. This was based on an estimated background seroprevalence in Australia of 1% [7,8]. The survey was hosted by the secure online database platform REDcap [9,10] and collected demographic details, including work site, and role within the organisation, questions about PCR proven infection and contact with a positive COVID-19 case. Blood samples were collected at all campuses during the 4-week study period.

Serology testing was run on the Roche Diagnostic Elecsys Anti-SARS-CoV-2 immunoassay [11] at Eastern Health Pathology. The assay uses a recombinant protein representing the nucleocapsid (N) antigen in a double-antigen sandwich assay format(11). All positive results were referred to the Victorian Infectious Diseases Reference Laboratory (VIDRL) for confirmation using a combination of different enzyme-linked immunosorbent assays

and neutralising antibody assays. A descriptive analysis was performed, with categorical variables reported as proportions. The main outcome measure of seroprevalence was calculated as the total number of participants who had reactive antibodies to SARS-CoV-2 as a proportion of the total number of participants.

Participants who reported a previous diagnosis of COVID-19 in their survey response were cross-referenced with in-house laboratory PCR results, a list of known infected staff, and direct confirmation with the individual. This was done to confirm the diagnosis of COVID-19 and establish site of acquisition (likely, unknown or not workplace related). Univariate logistic regression for detection of SARS-CoV-2 antibodies estimated odds ratios (OR) for different predictor variables. These were: place of work, role at work, travel overseas in 2020, experiencing symptoms of COVID-19 during the pandemic, having direct contact with a COVID-19 patient, and being placed on furlough (quarantined due to unprotected workplace exposure to an infectious COVID-19 case). Due to the small number of positive serology results, a multivariate analysis could not be performed. All analyses were conducted using STATA v16.1 (StataCorp, College Station, TX).

## Results

During the study period, 736 healthcare workers consented to the study and had blood samples collected. This represents approximately seven percent of the total Eastern Health workforce of 10,400. Of these 736 participants, complete survey responses were available for 706 (96%). Thirteen (2%) reported previous infection with SARS-CoV-2 – six were likely acquired at EH, three were infected elsewhere (known external exposure) and four were unknown. Sixteen (2.17%) participants had reactive antibodies for SARS-CoV-2 by in-house screening (Roche Elecsys immunoassay). All reactive antibodies tested at Eastern Health were completely concordant when tested at VIDRL.

Table 1 summarises participant demographics. The majority of participants were female (87%) and worked as nurses (53%). Ninety six participants (13%) had returned from overseas in 2020. Of the 16 participants with reactive antibodies, 13 (81%) had been diagnosed with COVID-19 by PCR during the year, and seven (44%) reported having direct contact with COVID-19 patients. Three of the 16 (19%) had been placed on furlough at some point during pandemic. Seropositive staff comprised of nurses ( $n = 11$ ), cleaning staff ( $n = 2$ ), allied health, medical and administrative staff ( $n = 1$  each). PCR results were available for 13 of the 16 participants who had positive serology. The median time from positive PCR to serology sampling was 4 months (range 1–8 months).

Of the three participants with positive serology but no previous positive PCR results (3/720, 0.42%), one was an allied health professional who had no previous contact with COVID-19 patients and had returned from the United Kingdom earlier in the year. Two were nurses; one had been identified as a close contact of a positive case and had been furloughed from work for a 14-day period of isolation

(remaining asymptomatic and negative by PCR testing during this period); the other had no known contact with any positive cases but had returned from the United Kingdom earlier in the year. Information on the timing of return from travel, and details regarding quarantine following travel were not collected. All three reported that they had experienced symptoms of COVID-19 at some stage in 2020.

Factors predicting likelihood of positive serology are also presented in Table 1. The analyses were conducted from 15 responses as one participant who had reactive antibodies did not complete the full survey. Participants aged under 30 had a higher rate of seropositivity but this was not statistically significant. Female gender, overseas travel in 2020, being placed on furlough, and providing direct care of to COVID-19 patients did not increase likelihood of positive serology. Having symptoms of COVID-19 in 2020 was associated with an increased risk of seropositivity (OR of 17.2  $p = 0.006$  95%CI: 2.25–131.55).

The only work group that was associated with a higher odds ratio for seropositivity was cleaning staff (OR 10.5  $p = 0.004$  95%CI: 2.08–52.64). It is important to note that only 12 cleaning staff participated in this study, thus the two who tested positive (representing 17% of this work group) had a significant impact on this analysis.

## Discussion

In this study we sampled 736 employees at a tertiary healthcare network in Victoria Australia, including front-line staff as well as non-patient facing and support staff. Based on this sample, we determined the seroprevalence of SARS-CoV-2 antibodies in healthcare workers at Eastern Health to be 2.17%. This was higher than previous estimates of seroprevalence in the Australian community, which ranged from 0.15% to 0.79% [7,8], however, these figures, calculated from samples collected prior to the second wave of infections, likely underestimate community seroprevalence.

The worldwide estimated seroprevalence in HCW is 8.7% [6], however rates as high as 24.4% have been reported [12] and reflect a spectrum of seropositivity dependent on geographical location and disease prevalence in the community. There have been no community seroprevalence studies conducted in the broader Victorian community to enable accurate comparison, particularly in the context of the second wave of infections. To the authors' knowledge, this is the first HCW seroprevalence study to be published in Australia, and is greatly significant as this reflects not only the low infection rates in the general Australian population, but also emphasises the positive impact of strategies implemented to reduce transmission, both in society, and within healthcare settings.

Symptomatic PCR testing, and testing of close contacts and furloughed staff led to the diagnosis of 61 infections with SARS-CoV-2 at EH, out of a workforce of approximately 10,400. This represents an infection rate of 0.59%, lower than the seroprevalence found in this study of 2.17%. We noted however, that the 13 participants in this study previously diagnosed with COVID-19 represented 21% of known EH HCW infections, whereas only seven percent of the

**Table 1** Participant demographics and variables predicting likelihood of positive serology.

Variable	n (%) of total study participants	n (%) of total with positive serology	n (%) of total without known COVID-19 diagnosis by PCR	Univariate model OR	P value (95% CI)
<b>Age<sup>d</sup></b>					
<30	152 (21)	6 (38)	2 (66)	1.0	–
31–40	143 (20)	3 (18)	0	0.3	0.197 (0.07–1.74)
41–50	164 (22)	5 (31)	1 (33)	0.8	0.664 (0.23–2.56)
51–60	186 (25)	2 (13)	0	0.3	0.107 (0.05–1.33)
>60	90 (12)	0	0	–	–
<b>Female gender</b>	621 (87)	15 (94)	3 (100)	2.1	0.469 (0.276–16.355)
<b>Hospital site</b>					
Box Hill Hospital <sup>c</sup>	276 (39)	8 (53)	1 (33.3)	1.8	0.260 (0.64–5.03)
Maroondah Hospital <sup>c</sup>	170 (24)	3 (20)	1 (33.3)	0.8	0.709 (0.22–2.81)
Wantirna Hospital <sup>c</sup>	70 (10)	3 (20)	1 (33.3)	0.8	0.709 (0.22–2.81)
Angliss Hospital	66 (9)	–	–	–	–
Peter James Centre	68 (10)	–	–	–	–
Healesville Hospital	23 (3)	1 (7)	–	2.2	0.463 (0.27–17.26)
Mental Health Services	8 (1)	–	–	–	–
Yarra Ranges Health	19 (3)	–	–	–	–
RACF	4 (0.5)	–	–	–	–
Other	2 (0.5)	–	–	–	–
<b>Role</b>					
Nurse	373 (51)	11 (70)	2 (67)	1.8	0.367 (0.61–5.34)
Doctor	96 (14)	1 (6)	0	0.44	0.441 (0.06–3.44)
Allied Health	87 (12)	1 (6)	1 (33)	0.5	0.509 (0.07–3.87)
Administrative	50 (7)	1 (6)	0	1.4	0.712 (0.19–11.46)
Cleaning staff	12 (2)	2 (12)	0	10.5	0.004 (2.08–52.64)
Pharmacist	12 (2)	0	0	–	–
Patient support assistant	11 (2)	0	0	–	–
Security	4 (1)	0	0	–	–
Pathology	45 (6)	0	0	–	–
Catering	3 (0.5)	0	0	–	–
Other	13 (2.5)	0	0	–	–
<b>Travelled overseas in 2020<sup>a</sup></b>	125 (17)	4 (25)	2 (66)	2.3	0.153 (0.73–7.49)
<b>Returned from<sup>b</sup>:</b>					
China	4	0	0	–	–
India	10	0	0	–	–
Indonesia	9	1	0	–	–
Japan	10	1	0	–	–
New Zealand	9	0	0	–	–
Philippines	6	0	0	–	–
Singapore	8	0	0	–	–
United Kingdom	8	2	2	–	–
United States of America	6	0	0	–	–
<b>Had symptoms in 2020</b>	336 (46)	14 (88)	3 (100)	17.2	0.006 (2.25–131.55)
<b>Furloughed in 2020</b>	97 (13)	3 (19)	1 (33)	2.4	0.191 (0.65–8.60)
<b>Direct care for COVID-19 patient</b>	253 (34)	7 (44)	1 (33)	1.9	0.221 (0.680–5.302)

OR, odds ratio; RACF, residential aged care facility.

Variable with no data indicated with “–” did not have a positive case.

<sup>a</sup> Other countries with <4 responses included: Argentina, Ireland, Israel, Italy, Malaysia, Mexico, The Netherlands, South Africa, Spain, Sri Lanka, Sweden, Thailand, Vanuatu, Vietnam and South Korea.

<sup>b</sup> % not shown due to small numbers.

<sup>c</sup> Sites where COVID-19 patients were housed.

<sup>d</sup> age group <30 was used as reference group.

overall workforce participated in our study. Our work mirrors a previous a sero-surveillance study of the general population in Australia and international studies which indicate that a significant proportion of infections are being missed by symptomatic or directed testing [7,13,14]. Despite this, our study only identified three HCW with positive serology who had not previously been diagnosed by PCR testing.

The diagnostic assay used in this study reports a sensitivity of 99.5% (95% CI 97.0–100%) in symptomatic patients, and specificity of 99.80% (95% CI 99.69–99.88%) [11]. All participants with confirmed PCR-based diagnoses developed antibodies against SARS-CoV-2, with one participant maintaining these antibodies for 8 months.

A previous meta-analysis of SARS-CoV-2 seroprevalence studies associated factors such as work in a COVID-19 unit, patient-related work, and positive household contacts with seropositivity [6]. In our study we found that direct contact with a positive COVID-19 case, or working in a COVID-19 ward, was not associated with an increased likelihood of seropositivity, mirroring HCW seroprevalence studies conducted in the United Kingdom and Germany [12,15]. This likely reflects the low infection numbers in general nationally. Australia closed its international borders in March 2020, and 13% of participants had returned from overseas countries during the pandemic, including countries with high infection rates such as the United Kingdom, the United States of America and India. Despite this, international travel was not associated with an increased risk of having positive serology.

Our study found that having symptoms of COVID-19 was associated with having a 17-fold greater odds of having positive serology. This is not unexpected, as PCR testing was encouraged for anyone with symptoms, no matter how mild. Similar findings have been reported in a HCW seroprevalence study conducted in the United Kingdom [12]. Specific details regarding symptoms for COVID-19 were not collected, such as frequency or timing of symptoms in relation to testing. As such it was not possible to link reported symptoms to PCR or serology test results. Our finding of increased risk of seropositivity associated with having COVID-19 symptoms may therefore be non-specific and cannot be characterised further.

Working as a cleaner was associated with higher odds of seropositivity, but this represents only two cleaning staff with reactive antibodies to SARS-CoV-2. Both of these participants had worked at sites that housed COVID-19 patients and had worked on COVID-19 wards. This may indicate a higher risk of COVID-19 infection, potentially due to the rigorous cleaning of contaminated surfaces and spaces or prolonged periods of time in such areas, increasing the risk of breaches to PPE. However, a detailed review of known employee infections at EH revealed that only one of these infections was thought linked to the workplace. Furthermore, only 12 cleaning staff participated in this study, representing 1% of all cleaning staff employed at Eastern Health. In contrast, 373 nurses participated, representing over half of our study participants, and 8% of all nurses employed at our health network. Whilst a clear association between working as a cleaner and SARS-CoV-2 infection cannot be established from our study, this link was demonstrated in another HCW seroprevalence study,

where 34.5% of housekeeping staff had reactive antibodies to SARS-CoV-2, higher than the study's overall seroprevalence of 24.4% [12].

Due to robust procedures and practices around infection prevention and control locally, high risk exposures such as working on COVID-19 wards were not found to be associated with seropositivity. Other factors that are likely to have contributed to this were the pre-emptive screening of staff in high risk areas such as emergency departments, and rapid contact tracing processes when staff infections were diagnosed. While this result should be reassuring for HCW at the frontline during this pandemic, the importance of continuing these high standards of infection control as COVID-19 vaccines are rolled out is paramount.

This study has several limitations. HCW previously diagnosed with COVID-19 in 2020 were more likely to participate, leading to selection bias. The sample size was also not symmetrical across all work groups and thus may not be truly representative of all HCW in our organisation. Whilst our use of work roles to define exposure risk may not equate with actual exposure risk, this aligns with the methodology used by other HCW seroprevalence studies [15–18]. Furthermore, our serology testing may have missed cases where antibodies for SARS-CoV-2 had waned prior to sampling, especially if the HCW were asymptomatic or minimally symptomatic [19,20], however we did not identify any participants with known COVID-19 diagnoses and negative serology. False positive serology results are also possible but unlikely as all positive results at Eastern Health Pathology were confirmed at VIDRL using a number of different assays.

Despite these limitations, this study demonstrates several important findings. Firstly, HCW were found to have a higher rate of SARS-CoV-2 infection than the general population, but the majority of cases had been detected previously by PCR based testing. We found only a small number of people with positive antibodies that had been missed by workplace efforts to detect and test staff through the pandemic. Even with this likely overestimated seroprevalence of SARS-CoV-2 in HCW at Eastern Health, seropositivity is very low compared to other countries, highlighting Australia's impressive achievement of minimising community and healthcare associated transmission.

## Ethics

Ethics approval was obtained from the Eastern Health Human Research Ethics Committee (approval no. LR20/096).

## Authorship statement

All authors had full access to all of the data in the study. JSYL and SG proposed and designed the study protocol. JSYL and MP performed the data collection. JSYL and PB conducted the analysis. JSYL, PB, RC, SG and EN drafted the manuscript. All authors have reviewed and approved the manuscript prior to submission.

A copy of the online staff survey used in this study is available as an [appendix](#).

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## Provenance and peer review

Not commissioned; externally peer reviewed.

## Conflict of interest

The authors have no conflicts of interest to disclose.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.idh.2021.03.004>.

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