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# SARS-CoV-2 infection in mortuary and cemetery workers

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ABSTRACT

*Background:* Mortuary and cemetery workers may be exposed to the bodies of people with SARS-CoV-2 infection; however, prevalence of infection among these groups is unknown.
*Methods:* Nasopharyngeal swabs (NPS) for RT-PCR and serologic testing for SARS-CoV-2 were performed on mortuary and cemetery workers in Qatar. Data on specific job duties, living conditions, contact history, and clinical course were gathered. Environmental sampling was carried out to explore any association with infection. Logistic regression analysis was used to determine the factors associated with infection.
*Results:* Forty-seven mortuary workers provided an NPS and seven (14.9%) were PCR positive; 32 provided a blood sample and eight (25%) were antibody positive, six (75%) who were seropositive were also PCR positive. Among the 81 cemetery workers, 76 provided an NPS and five (6.6%) were PCR positive; 64 provided a blood sample and 22 (34.4%) were antibody positive, three (13.6%) who were seropositive were also PCR positive. Three (22.2%) and 20 (83.3%) of the infected mortuary and cemetery workers were asymptomatic, respectively. Age <30 years (OR 4.9, 95% CI 1.7–14.6), community exposure with a known case (OR 4.7, 95% CI 1.7–13.3), and presence of symptoms in the preceding 2 weeks (OR 9.0, 95% CI 1.9–42.0) were independently associated with an increased risk of infection (PCR or antibody positive). Of the 46 environmental and surface samples, all were negative or had a Ct value of >35.
*Conclusion:* A substantial proportion of mortuary and cemetery workers had evidence of SARS-CoV-2 infection, which was incidentally detected upon serologic testing. These data are most consistent with community acquisition rather than occupational acquisition.


## Introduction

As of 15 December 2020, more than 73 million people have been infected with SARS-CoV-2 and over 1.6 million deaths have been reported worldwide (Worldometer, 2021). Viral RNA can remain detectable for more than 100 days in 6.6% of patients after clinical recovery from initial infection; 5% their close contacts develop IgG antibodies, suggesting past exposure (Chirathaworn et al., 2020). Asymptomatic people are also well-documented transmitters of infection. Seropositivity for SARS-CoV-2 among healthcare workers varies between 3%–17% (Chen et al., 2020; Fusco et al., 2020). In Qatar, 10.6% of the 16,912 healthcare workers were found to be PCR positive on nasopharyngeal swab (NPS) specimen, although most exposures were outside the work environment (Alajmi et al., 2020).

Mortuary and cemetery workers handling the bodies of confirmed or suspected cases of SARS-CoV-2 infection may be at an increased risk of infection. There are numerous published guidelines on handling of corpses with SARS-CoV-2 infection, and management of mortuaries and cemeteries during the SARS-CoV-2 pandemic (Dijkhuizen et al., 2020; Finegan et al., 2020; Fineschi et al., 2020; Khoo et al., 2020; McGuone et al., 2020; Rani, 2020; Vidua et al., 2020; Yaacoub et al., 2020). However, there are no data

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regarding the incidence or prevalence of SARS-CoV-2 infection among these groups or presence of the virus on environmental surfaces in these areas. This study aimed to determine the rate of SARS-CoV-2 infection among mortuary and cemetery workers in Qatar and the possible risk factors for infection.

## Methods

The study was conducted in Qatar between 10 March and 06 October 2020. Qatar has a population of 2.8 million, with >85% of the population being expatriate workers (Al Kuwari et al., 2020; Alajmi et al., 2020; Butt et al., 2020). The first case of SARS-CoV-2 infection in Qatar was reported on 28 February 2020 in a returning traveler. The first locally transmitted case was reported on 06 March 2020 (Al Kuwari et al., 2020). It is mandatory to report all deaths in the country and all mortuary services in Qatar are handled by Hamad Medical Corporation, which is the public hospital system consisting of 14 facilities and providing approximately 85% of inpatient bed capacity in Qatar. A specific protocol for handling the bodies of all deceased people with SARS-CoV-2 infection was immediately instituted after the identification of the first case in Qatar. This included training of all mortuary staff in the proper and mandatory use of full personal protective equipment, double plastic bagging of the deceased bodies, environmental cleaning, limitations on number of people allowed for final rituals, while maintaining physical distancing, and quick burial without any physical contact with the deceased body or casket by attendants other than those responsible for last rituals. Mortuary staff subsequently trained cemetery workers on the same protocols.

This study identified all mortuary and cemetery workers through Human Resources Department records and confirmed by interviewing site supervisors. Structured questionnaires and interviews were administered to gather demographic and clinical information, presence of symptoms, type of accommodation, exposure history, and detailed nature of the work performed by each participant. All workers (except those unavailable due to leave or other absence at multiple visits) at both sites were tested for SARS-CoV-2 infection through an NPS using RT-PCR. PCR testing was performed using real-time reverse-transcription PCR (RT-qPCR) using the TaqPath™ COVID-19 Combo Kit (Thermo Fisher Scientific, USA), AccuPower SARS-CoV-2 Real-Time RT-PCR Kit (Bioneer, Korea) or Roche cobas® SARS-CoV-2 Test (Roche, Switzerland). Nasopharyngeal swab samples for PCR were collected on 01 July 2020 for the cemetery workers and on 17 September 2020 for the mortuary workers.

Environmental samples were collected from the mortuary and cemetery sites, including the external surfaces of the bags containing deceased bodies. SARS-CoV-2 RNA was extracted from the environmental samples using Quick-RNA Viral Kits (Zymo Research, Irvine CA, USA Cat. No. R1041). Viral detection was performed using the SARS-CoV-2 (2019-nCoV) CDC qPCR Probe Assay Research Use Only (RUO) kit (Integrated DNA Technologies, IDT, Coralville, IA, USA Cat number 10006713). All RT-qPCR amplifications were performed using the Luna Universal Probe

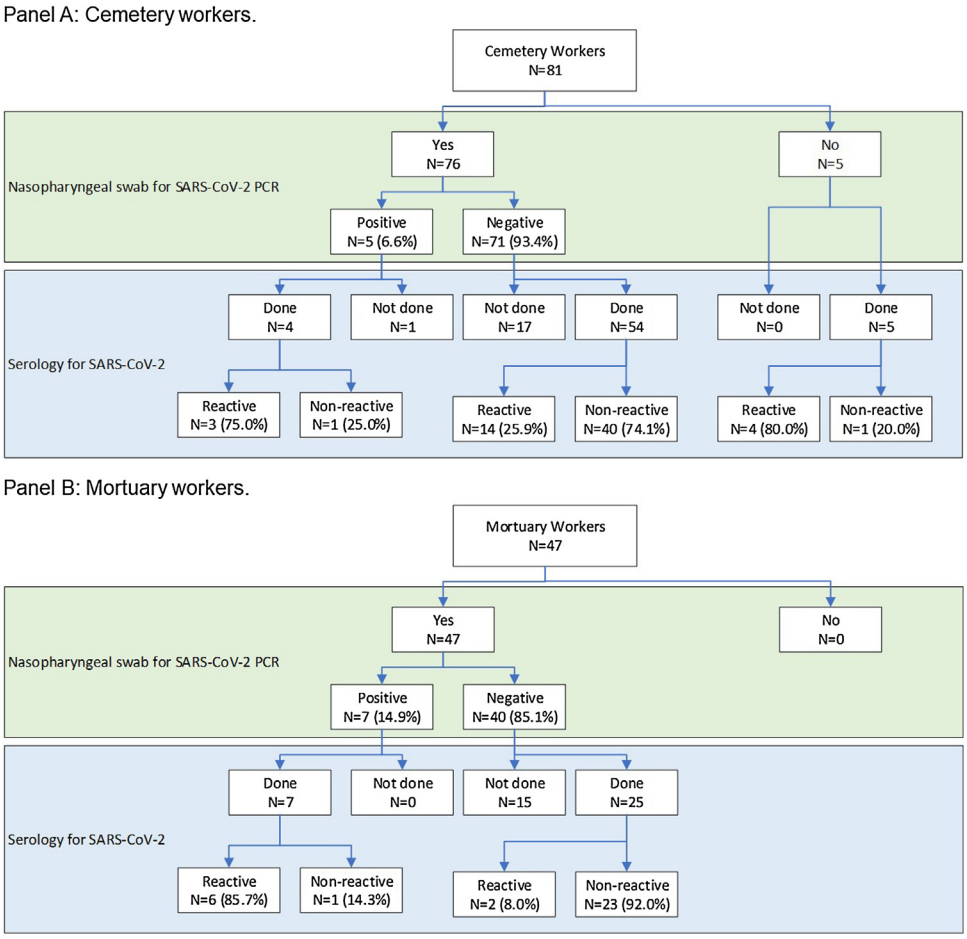


**Figure 1.** Flow chart of SARS-CoV-2 testing for the study population.

One-Step RT-qPCR Kit (New England BioLabs, Ipswich, MA, USA Cat number E3006E). RT-qPCR assays were performed in 96-well plate on an Applied Biosystems 7500 Fast Real-Time PCR Instrument (Applied Biosystems, CA, USA). (See Appendix for detailed methods for PCR testing).

Serologic testing was offered to all workers at both sites. Blood was obtained on 01 September 2020 from the cemetery workers and on 17 September 2020 from the mortuary workers (Supplementary table). Those who agreed to provide blood samples for serologic samples were included. Testing for SARS-CoV-2-specific antibodies in the serological samples was performed using an electrochemiluminescence immunoassay, the Roche Elecsys® Anti-SARS-CoV-2 (Roche, Switzerland). Results were interpreted as per the manufacturer's instructions: reactive for cutoff index ≥1.0 and non-reactive for cutoff index <1.0. All laboratory testing was conducted at Hamad Medical Corporation central laboratory following standardized protocols. The laboratory is accredited by the College of American Pathologists.

Baseline characteristics were compared between mortuary workers and cemetery workers using the *t*-test or Chi-squared test, as appropriate. A logistic regression model was used to calculate the odds ratios and 95% confidence intervals for factors associated with infection (PCR or antibody positivity). First, a univariable logistic regression was constructed and variables significant at a p-value of ≥0.2 were included in the multivariable model.

The study was approved by the Institutional Review Board at Hamad Medical Corporation. A waiver of informed consent was granted because the original testing was performed under a national public health emergency mandate.

## Results

This study identified 47 mortuary and 81 cemetery workers (Figure 1). All 47 mortuary workers provided an NPS and seven (14.9%) were positive by PCR. Thirty-two provided a blood sample for serologic testing and eight (25.0%) were antibody positive. Six (75%) who were seropositive also tested positive for PCR. Among the 81 cemetery workers, 76 provided an NPS and five (6.6%) tested positive by RT-PCR. Sixty-four provided a blood sample for serologic testing and 22 (34.4%) were antibody positive, three (13.6%) of those who were seropositive tested positive for PCR (Figure 1). Baseline characteristics of the two groups are provided in Table 1. Notably, three (22.2%) and 20 (83.3%) of the infected mortuary and cemetery workers were asymptomatic (p = 0.01); 88.9% of the SARS-CoV-2 infected mortuary workers and 91.3% of the cemetery workers had no known or reported comorbidities. None of the cemetery workers and two (4.3%) of the mortuary workers were hospitalized for SARS-CoV-2 infection and there were no deaths (Table 2). To provide perspective, there were 216 SARS-CoV-2-related deaths in Qatar as of 06 October 2020 (the last day of the study). The median (IQR) Ct values were 34.5 (29.6, 35.8) for those with non-reactive serologic test and 21.9 (17.4, 32.4) for the reactive serologic test (p = 0.1).

On multivariable logistic regression analysis, factors associated with an increased risk of being infected (either PCR or antibody positive) included age <30 years (OR 4.9, 95% CI 1.7–14.6), history of contact with a confirmed case (OR 4.7, 95% CI 1.7–13.3), and presence of symptoms in the preceding 2 weeks (OR 9.0, 95% CI 1.9–42.0) (Table 3).

A total of 45 environmental samples were obtained from the mortuary (n = 15) and cemetery (n = 30) sites. Semi-quantitative analysis using cycle threshold counts (Ct values) as a surrogate for viral load revealed that all environmental samples were either negative or had a Ct value of >35 (Table 4).

**Table 1**
Baseline characteristics.

| | Mortuary staff (n = 47) | Cemetery staff (n = 81) |
|---|---|---|
| Median age (IQR), years | 39 (30, 51) | 38 (30.5, 49) |
| Male sex (%) | 41 (87.2) | 67 (82.7) |
| Nationality, n (%) | | |
| Indian | 22 (46.8) | 5 (6.2) |
| Nepalese | 4 (8.5) | 6 (7.4) |
| Pakistani | 6 (12.8) | 32 (39.5) |
| Iranian | | 10 (12.3) |
| Egyptian | 3 (6.4) | 4 (4.9) |
| Bangladeshi | 1 (2.1) | 10 (12.3) |
| Qatari | 2 (4.3) | 5 (6.2) |
| Sudanese | 4 (8.5) | 5 (6.2) |
| Others | 5 (10.6) | 4 (4.9) |
| Type of accommodation, n (%) | | |
| Single | 0 | 2 (2.5) |
| Shared | 24 (51.1) | 53 (65.4) |
| Family | 17 (36.2) | 26 (32.1) |
| Missing | 6 (12.8) | 0 |
| Job category, n (%) | | |
| Mortuary attendant | 37 (78.7) | 15 (18.5) |
| Transportation | 0 | 15 (18.5) |
| Grave digger | 0 | 12 (14.8) |
| Security guards | 0 | 18 (22.2) |
| Clinical services | 3 (6.4) | 0 |
| Administrative and support staff | 7 (14.9) | 9 (11.1) |
| Others | 0 | 12 (14.8) |
| Median education years (IQR) | 12 (12,14) | 10 (0,12) |

## Discussion

It is believed that this is the first study to report the prevalence of SARS-CoV-2 infection among mortuary and cemetery workers. While acute infection, as determined by PCR positivity on an NPS, was low (14.9% of mortuary workers and 6.6% of cemetery workers), evidence of past or occult infection (as determined by seropositivity) was much higher (17% of mortuary workers and 27.2% of cemetery workers).

Mortuary and cemetery workers are at a high risk of SARS-CoV-2 infection due to exposure to potentially infected deceased bodies. While there is heightened awareness of such risk in the current pandemic situation, and multiple guidelines have been published on the safe handling of deceased people, the adherence to such guidelines is unknown. The State of Qatar has also implemented strict infection prevention and control guidelines on the handling of deceased people throughout the process of admission to the mortuary to actual burial. The rate of overt infection in a similar population of craft and manual workers in Qatar ranged between 0%–10% between June and September 2020, with a pooled mean PCR positivity rate of 3.9% (Jeremijenko et al., 2020). Furthermore, the rate of PCR positivity among healthcare workers at Hamad Medical Corporation was 10.6% among 16,912 healthcare workers who were tested and mostly acquired from non-patient contacts (Alajmi et al., 2020). Numerous factors may account for these differences, including chances of contact with confirmed infected persons, living situation, and adherence to personal protective equipment use. Symptoms consistent with respiratory illness were reported in a much higher proportion of workers compared with published literature. This is likely due to an indication-for-intervention bias, whereby those with symptoms were more likely to be tested.

History of contact with a known living confirmed case was among the strongest risk factors associated with infection. This is intuitive, but also a cautionary sign indicating that the risk of acquiring infection from contacts in the community is likely higher than the risk from caring for patients in a hospital. It is quite possible that healthcare workers are more diligent in adhering to

**Table 2**
Characteristics of people with confirmed infection (PCR or antibody positive).

| | Mortuary staff N = 9 | Cemetery staff N = 24 |
|---|---|---|
| PCR positive, n (%) | 7[a] (77.8%) | 5 (22.8%) |
| Median (IQR) Ct Values | 24.82 (17.85, 31.79) | 27.17(14.73, 39.62) |
| Antibody positive, n (%) | 8 (88.9%) | 22 (91.7%) |
| Median (IQR) antibody titer | 22.25 (6.97, 62.48) | 64.8 (13.33, 106.75) |
| History of contact with COVID-19 confirmed cases, n (%) | | |
| Absent | 4 (44.4%) | 1 (4.2%) |
| Present | 5 (55.6%) | |
| Not sure | 0 | 23 (95.8%) |
| Clinical symptoms | | |
| No | 3 (33.3%) | 20 (83.3%) |
| One or two | 1(11.1%) | 2 (8.3%) |
| Three or more | 5 (55.6%) | 2 (8.3%) |
| Hospitalisation | 2 (22.2) | 0 |
| Quarantine admission | 5 (55.6%) | 3 (12.5%) |
| Comorbidities | 1(11.1%) | 3 (12.5%) |

[a] One was non-reactive for antibody.

**Table 3**
Factors associated with SARS-CoV-2 infection (confirmed by reverse transcriptase polymerase chain reaction and/or serology by multivariable logistic regression analysis).

| | Multivariable regression analysis | | |
|---|---|---|---|
| | Odds ratio | 95% CI | p-value |
| Age < 30 years | 4.918 | (1.656–14.603) | 0.004 |
| Shared accommodation | 3.252 | (0.958–11.040) | 0.059 |
| Mortician *vs* non mortician | 2.151 | (0.55–8.416) | 0.271 |
| Cemetery *vs* mortuary | 3.204 | (0.683–15.035) | 0.14 |
| History of contact with a known living SARS-CoV-2 confirmed case | 4.694 | (1.66–13.27) | 0.004 |
| Presence of symptoms 2 weeks before test | 8.989 | (1.925–41.979) | 0.005 |

**Table 4**
Environment contamination with SARS-CoV-2 in mortuaries and cemeteries.

| Area | Description | Ct values[a] |
|---|---|---|
| Mortuary samples (n = 15) | | |
| Body bags (n = 3) | Surface swabs | 45, 45, and 38 |
| Storage freezer/fridge areas | Freezer/fridge surfaces | 35, 45, 45, 35, and 45 |
| | Body trays in freezer/fridge | 45 and 45 |
| Other surfaces | Mortuary floor and air conditioner | 45 and 45 |
| | Toilet, toilet mop, and floor | 45, 45, and 45 |
| Cemetery samples (n = 30) | | |
| Administration building | Toilet, sofa and chairs | 45, 37, and 38 |
| Drivers' waiting room | Air conditioner and filter, sofa, chairs, floor, fridge and toilet | 45, 45, 45, 45, and 39 |
| Waiting area outside the deceased body washing | Sofa 1, sofa 2, floor, and air conditioner | 45, 45, 45, and 45 |
| Deceased body washing area (COVID-19 tagged) | Surfaces, washing tray, and air conditioner, wash basin | 45, 45, 45, and 45 |
| Deceased body washing area (not COVID-19 tagged) | Air conditioner, surfaces, and washing slab | 38, 45, and 45 |
| Cold Store for deceased bodies | Floor, surfaces, trolley, and air conditioner | 45, 37, and 45 |
| Mosque | Door and dead body keeping area | 38 |
| Family waiting area inside washing facility | Toilet, surfaces, sofa, and air conditioner | 45, 45, 37, 45, 45, and 45 |

[a] A value of 45 indicates that no viral RNA was detected after 45 cycles, and thus considered negative.

precautionary measures when working in a high-risk environment, as borne out by the previous finding of a higher rate of infection in healthcare workers at non-COVID-designated facilities compared with those working at designated COVD facilities (Alajmi et al., 2020).

Environmental samples either did not demonstrate the presence of the virus or at very high Ct values, suggesting a low amount of virus or non-viable virus. In clinical laboratory testing for SARS-CoV-2, Ct values of >30 are generally associated with non-culturable or non-viable virus (Gniazdowski et al., 2020; Jeremijenko et al., 2020). It is unknown whether environmental samples show the same association between Ct values and viral viability. Human clinical sample are presumably fresh, while environmental samples could represent viral contamination days or weeks earlier, thus making the interpretation of transmission difficult.

The current study results should be interpreted with some caution. While this is the first systematic evaluation of infection in mortuary and cemetery workers, and provides robust estimates, the characteristics of this group of workers in Qatar may be different from similar workers in other countries. Living situation and likelihood of contact with confirmed or suspected cases may also be different among these workers in Qatar compared with other countries. The current sample was small, which is reflective of the relatively small population of Qatar and low number of deaths. For environmental samples, viral viability was not

determined and therefore differentiation between live, infectious virus and viral fragments which are non-viable could not be performed.

In conclusion, the prevalence of SARS-CoV-2 infection in mortuary and cemetery workers was substantial. Infections were asymptomatic in 83% of the cemetery workers and 33.3% of the mortuary workers, and mostly incidentally detected through serologic testing. The risk of acquiring infection appears to be driven by community spread rather than occupational exposure. This underscores the need for continued public health measures in the population until most of the population is vaccinated and/or achieves herd immunity.

## Conflict of interest

None declare.

## Funding

None.

## Ethical approval

The study was approved by the Institutional Review Board at Hamad Medical Corporation. A waiver of informed consent was granted because the original testing was performed under a national public health emergency mandate.

## Author contributions

Drafting of the manuscript: AAB, HN-H; data acquisition: HN-H, HE, ME, AGT, RAAF, MAAA, MA, AJ; laboratory testing and reporting: MB, BA, AA, PC

Study design: AAB, HN-H, MA, ABAS, AJ, JAA, HE; data analysis: HN-H; data interpretation: AAB, HN-H, AJ, ABAS; critical appraisal and review: MA, AJ, HN-H, JAA, ME, RAAF, AGT, MAAA, AA, MB, BA, PC, HE, ABAS, AAB. Dr. Moza Alishaq had access to all data at all times and takes responsibility for the accuracy of data.

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## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijid.2021.03.012.

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