Prevalence of Antibodies to SARS-CoV-2 in Irish Healthcare Workers

Phase 1 October 2020

Interim Report

19th January 2021

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(Prevalence of Covid-19 in IriSh hEalthcare workers)

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Summary (main document page 9)

Background

Healthcare workers, and those they live with, are at increased risk of contracting the COVID-19 virus (1) (2) (3). To date there are no published literature on the seroprevalence of antibodies to SARS-CoV-2 infection in Irish Healthcare workers (HCW). Understanding the transmission and potential immunity dynamics in hospitals in Ireland remain key factors in controlling this pandemic at national level. St. James' Hospital (SJH) in Dublin's south inner city has almost 4,700 employees. From March-May 2020 9.6% of this workforce tested positive for SARS-CoV-2 infection via PCR, and by the start of October 10.2% of staff had tested positive by PCR. University Hospital Galway (UHG) is a comparable hospital with almost 4400 employees; 1.8% had a confirmed infection at some stage during the time-period from March-May 2020 and this remained at 1.8% until the start of October 2020. The community incidence of COVID-19 infection in County Galway was significantly lower than in County Dublin during this time period, which covered the first wave of the pandemic in Ireland, and the start of the second wave (4). The community seroprevalence was also significantly lower (5) (6).

The purpose of the study was to calculate the prevalence of anti- SARS-CoV-2 antibodies in HCW in these two hospitals with diverging community and healthcare rates of infection, in order to understand HCW risk factors (demographic, living arrangements and work-related risks) for SARS-CoV-2 infection and to help health services to prepare for further waves of the pandemic. The study will be repeated in March/April 2021 to assess changes in overall seroprevalence, as well as changes in individual serostatus over time, and antibody response to vaccination.

Methods

Study Design

This is a longitudinal seroprevalence study, consisting of two sero-surveys six months apart, in October 2020 and in April 2021. This document pertains to the first seroprevalence study carried out from 14th-23rd October 2020. Ethical approval was obtained from the National Research Ethics Committee for COVID-19. Funding was secured through the Health Service Executive

(HSE). All staff members of both hospitals were invited to participate in an online self-administered consent and questionnaire, followed by blood sampling. Technical support and walk-in phlebotomy clinics were provided for participants who had difficulty with online consent. Blood samples were processed anonymously. All samples were tested on two testing platforms; these were the Abbott Architect SARS -CoV-2 immunoglobulin (Ig)G assay as used for the Study to investigate COVID-19 infection in People Living in Ireland (SCOPI) (4) and the Roche Elecsys anti-SARS-CoV-2 immunoassay (7) (8) (9). Samples with an index result in the Abbott manufacturers suggested positive and grayzone underwent additional testing in the National Virus Reference Laboratory (NVRL) using the Wantai SARS-CoV-2 AB ELISA distributed by Fortress Diagnostics (8). A positive result on any of the three assays was considered a positive result. Results were issued by the study team to all participants who requested their result.

Statistical analysis

Frequencies and percentages were calculated for sociodemographic, epidemiological, and clinical characteristics, including antibody results. Characteristics of those with a positive SARS-CoV-2 antibody result were compared to those with undetectable antibody, using the chi-square test. Univariate logistic regression was used to calculate relative risks along with their 95% confidence intervals to assess the association between SARS -CoV-2 antibody result and characteristics of the study participants. Multivariable regression analysis was conducted to control for negative and positive confounding and to calculate adjusted relative risks (aRR).

Results

Participation rates and demographics

All staff working in SJH and UHG (9,038 people) were invited to participate in the study. In SJH, 65% (3042/4692) of staff participated in both questionnaire and blood sample; 63% (2745/4395) in UHG.

The socio-demographic characteristics of participants were similar in both hospitals. Seventy-seven percent were female, with a median age of 39.5 (IQR 30.4-48.9); 5.1% of participants were >60 years of age; 77% of participants were white Irish, 10% Asian (13% in SJH and 7% in

UHG), 9.5% other white background (majority born in Poland, USA, UK), 2% African or any other black background. Ninety-one percent of participants live with others, and 31% live with other HCWs. The majority (36%) of participants were nursing staff, followed by allied health care staff (19%), medical/dental staff (17%), administration staff (13%), general support staff (7.5%), healthcare assistants (HCA) (5%) and other (2%), broadly reflecting the HCW breakdown of the hospital staff. Participation rates among staff groupings were also similar in both hospitals.

Previous testing

SJH staff had a higher rate of previously confirmed infection; 9.6% of SJH participants reported having tested positive at some stage by PCR compared to 2.7% of UHG participants.

Seroprevalence

In SJH 15% (464/3042) of all participants had detectable SARS-CoV-2 antibodies, and 21% (108/510) of participants reporting daily contact with patients with known or suspected COVID-19 infection (high-risk group) had detectable antibodies. In UHG 4.1% (112/2745) of all participants had detectable SARS-CoV-2 antibodies, 7.1% (28/392) of those in the high-risk group.

SARS-CoV-2 antibody and previous diagnosis and symptoms

Ninety-five percent of those who had previously confirmed infection by PCR had a detectable antibody. In total 226/576 (39%) of those with positive antibodies had never been diagnosed with COVID-19 infection. This represented 3.9% of all participants having had an undiagnosed infection. Sixteen percent (90/576) of those with detectable antibodies reported never having experienced symptoms consistent with COVID-19.

Characteristics of and risk factors for antibody positivity

On combined data for both hospitals, those with detectable antibodies were more likely to be of male sex and in the 18-29-year age group; 12% of all participating males had detectable antibody versus 9.4% of females ($p=.013$), and 13% of all participants aged 18-29 were antibody positive ($p<.001$). Regarding ethnicity 19% of Asian participants and 14% of participants of African or

other black background were seropositive, versus 8.6% of white Irish participants (p<.001). Ten percent of those living with others had detectable antibody compared to 5.9% of those living alone (p=.007), and 13% of those living with other HCWs had detectable antibodies compared with 8.5% of those not living with HCWs (p<.001). Nineteen percent of those who reported at least one close contact with a confirmed case had detectable antibody, 6.1% of those who had never had a close contact event (p<.001); 27% of those in whom the contact was in the community or household had detectable antibody, versus 18% of those in whom the close contact event was in the workplace (p=.002).

Divided by hospital, the characteristics of those participants who were antibody positive differed on sex and working role. The higher prevalence of antibodies in males was more pronounced in UHG participants. In terms of role, in SJH the highest seroprevalence was seen in HCAs (27%), followed by nurses (21%) and doctors (14%), whereas in UHG this was doctors (6.9%), HCAs (6.2%) and nurses (4.7%).

On multivariable analysis of the combined hospital data the adjusted relative risk of detectable antibody was higher for the following characteristics: working in SJH as opposed to UHG (aRR 3.7, 95% CI 3.0-4.5. p<.001), being a healthcare assistant (aRR 2.0, 95% CI 1.4 – 3.0, p 0.001), a nurse (aRR 1.6, 95% CI 1.1 – 2.2, p 0.007), daily exposure to patients with confirmed or suspected COVID-19 infection (aRR 1.6, 95% CI 1.2-2.1, p 0.002), daily contact with patients not known or suspected to have COVID-19 infection (aRR 1.4, 95% CI 1.1-1.8, p 0.008), age 18-29 (aRR 1.4, 95% CI 1.1-1.9, p 0.006), living with others (aRR 1.5, 95% CI 1.0-2.1, p 0.048), living with other HCW (aRR 1.3, 95% CI 1.1 – 1.5, p 0.007), being of Asian background (aRR 1.3, 95% CI 1.0-1.6, p 0.028) and male sex (aRR 1.2, 95% CI 1.0-1.4, p = 0.046).

Discussion

Overall seroprevalence

The seroprevalence between SJH and UHG differed by four-fold, with an aRR of 3.7 for working in SJH, reflecting the difference in seroprevalence in the community in the two locations (5). The seroprevalence in the hospital setting was approximately six times the community seroprevalence found in the SCOPI study for both geo-areas with lower and higher

seroprevalence (5). The seroprevalence in SJH was similar to that found in a recent study in Tallaght University Hospital, also in Dublin (10), suggesting that the main risk for HCW infection is the community incidence. The seroprevalence in both hospitals fell within the wide range previously described in other studies, and fell either side of the European estimate of 8.5% from the meta-analysis published in November (11).

Seroprevalence by role and type of patient contact

The higher seroprevalence amongst HCAs, followed by nurses and doctors reflects the degree of proximity to patients that is required by each of these working roles- a recognized risk factor for disease acquisition (12). On multivariable analysis being a HCA carried the highest relative risk of antibody positivity of any of the characteristics evaluated in our study, even after controlling for the effect of patient proximity. The seroprevalence was higher in the high-risk group in our study (those with daily contact with patients with known or suspected COVID-19 disease). Studies have differed on this result (13) (14).

Previous symptoms and testing

In both hospitals, the seroprevalence was significantly higher than the known diagnoses of COVID-19 infection (15% vs 10.2% in SJH, and 4.1% vs 1.8% in UGH). Sixteen percent of participants with positive antibodies reported having never experienced symptoms at any stage that were consistent with infection with COVID-19. In total, at least 226 (39%) of infections in our study were undiagnosed and therefore it is likely that these HCWs were working during the infectious period, with potential for onwards transmission to patients and other staff members if proper use of PPE and adherence to IPC measures are not strictly adhered to, and especially in those who were symptomatic (15). This highlights the importance of early detection and reinforces the necessity for universal adherence to standard infection control precautions at all times, compliance with transmission-based precautions and appropriate use of PPE including face masks in the hospital setting (16). This finding also supports the recommendation for screening of asymptomatic staff when a patient case of hospital-acquired infection, or hospital outbreak of infection with COVID-19 occurs (17). Consideration may also need to be given to mass serial screening of asymptomatic HCWs, which has been shown to be useful in certain settings (18) (19). However, other studies have found the impact of this intervention to be

uncertain and the logistical challenges it poses to the health service are not insignificant (20) (21) (22).

Risk factors for antibody positivity

The main risk factors identified to be significantly associated with antibody positivity were

- Working in SJH
- being a HCA
- being a nurse
- being of Asian ethnicity
- performing roles associated with close patient contact (especially those working directly with patients known or suspected to have COVID-19 infection)
- being aged 18-29
- being male

Similar risk factors have also been identified in other studies, including the meta-analysis of European studies (23) (11). Those of Asian background had a higher risk than those of white Irish background. It is possible that there are other social factors relating to ethnicity that were not evaluated in our study and that are contributing to this risk. Other studies have highlighted close patient contact as a risk factor for disease acquisition, including specifically the role of nurse or HCA (23) (24).

Having a household contact is known to be a significant risk factor for disease acquisition (25). In our study, living with others (and especially living with other HCWs) was significantly associated with being antibody positive, which supports the theory that at least a proportion of the HCWs contracting COVID-19 are doing so in their home environment. We also showed that for those who had a close contact event, the majority reported this close contact to have occurred in the workplace. It is noteworthy that there was less access to testing in the community than in the workplace. However, the seroprevalence was higher in those who reported a close contact in the community or household outside, rather than at work. Other studies have found some correlation between size of household and antibody positivity (14) but to the best of our

knowledge ours is the first study to find a statistically significant correlation between living with other HCWs and being antibody positive.

Conclusion and Recommendations

The overall seroprevalence of antibodies to SARS-CoV-2 was 15% in SJH and 4.1% in UHG, reflecting the difference in community transmission and diagnosed disease incidence in each geographical area and each hospital during the first wave of the pandemic, and suggesting that the main risk factor for acquisition of COVID-19 infection in HCW is the community incidence. The HCW seroprevalence was six times the community seroprevalence in each geo-area. The increased risk was in all HCWs in both hospitals, but certain groups were more at risk. Specific risk factors for antibody positivity included being a HCA or nurse, daily contact with patients (especially those known or suspected to have COVID-19 infection), age 18-29, living with others, in particular living with other HCWs, being of Asian background, and being male. The degree of previously undiagnosed and asymptomatic infections highlights the need for ongoing universal adherence to infection control guidance including the use of appropriate personal protective equipment (PPE) in the hospital setting, as well as the importance of early case detection. It is essential that all HCWs have easy access to testing, even with mild symptoms. Screening of asymptomatic HCWs in the setting of hospital-acquired patient infection or outbreaks is important and regular screening of asymptomatic HCWs needs to be considered depending on local epidemiology. As the national COVID-19 vaccination programme is rolled out we expect that access to testing for HCWs will still be critical.

This national study highlights the different epidemiology in two comparable hospitals in different locations. This study is paramount in improving understanding of transmission dynamics and HCW risk factors (demographic, workplace- and household-related) in hospitals in Ireland. This study will be crucially important in informing the vaccination strategy of HCWs in Ireland. Finally, these results and resulting recommendations may be used to inform future public health responses at local and national level in other similar institutions.

Prevalence of Antibodies to SARS-CoV-2 Infection in Irish Healthcare Workers (PRECISE)

Phase 1 of testing October 2020

Interim Report - Main document

19th January 2021

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On behalf of the PRECISE Study Steering Group

(Prevalence of Covid-19 in IriSh hEalthcare workers)

Background

The SARS-CoV-2 virus was first identified in December 2019 in Wuhan, China, and spread rapidly internationally to cause the most significant pandemic since the Spanish Influenza of 1918, with over 70 million cases worldwide and death toll of 1.6 million by December 2020 (26).

Healthcare workers (HCWs), and those that they live with, are at increased risk of contracting COVID-19 viral disease (1) (2) (3) (27) (28). HCWs risk acquisition of infection from patients and from each other, and risk passing it to household members (12). For multiple reasons, including absence of symptoms, access to PCR testing, stigma, lack of motivation to test, and test sensitivity, only a proportion of total infections in a population will be diagnosed at the time of infection. Seroprevalence studies are useful to estimate the true prevalence of past infection in

a population group (29). Although the correlation between antibody positivity and immunity is not yet fully understood for COVID-19, seroprevalence studies can also help to estimate potential immunity in the target population, as well as to identify sub-groups at higher risk of infection acquisition, and groups that should be targeted for vaccination. They can also help to quantify the proportion of asymptomatic infections (29) (30).

SARS-CoV-2 antibody seroprevalence studies have been conducted in HCW in numerous European countries showing widely varying antibody positivity proportions of between 1% and 45% (13) (14) (31) (32) (33) (24). A large meta-analysis showed an overall seropositivity of 8.5% in European HCW (11). Risk of antibody positivity has been correlated with degree of patient contact (31) (33) (34). Studies have also shown that a significant proportion of infections are asymptomatic (35). HCW who have asymptomatic infection risk unknowing onwards transmission either in the work or home environment (30) (36).

Up until the beginning of December, Ireland had had one of the lowest incidence of COVID-19 infection of any European country (6) (26) (37). By the first week of December 2020 Ireland had had just over 75,000 infections, and 2120 death, resulting in a cumulative attack rate of 0.015% and a mortality rate of 2.8% (6) (26). From mid-December 2020 until the time of writing in early January 2021, the incidence of COVID-19 in Ireland increased dramatically (6). The Study to investigate COVID-19 Infection in People Living in Ireland (SCOPI) which took place in June/July 2020 tested for antibodies to COVID-19 in members of the community in two areas of Ireland; results showed significantly higher antibody prevalence in the Dublin area (3.1%) with comparison to the Sligo area (1.8%) (5). This was in keeping with the difference in incident rates of infection in the two communities during the first wave of the pandemic. The national seroprevalence was estimated at 1.7%. This was three times higher than the number of PCR-diagnosed infections. Almost three quarters of the population sampled had experienced symptoms consistent with COVID-19 viral disease (5).

To date there are no published literature on the seroprevalence of antibodies to COVID-19 infection in Irish Healthcare workers (HCW). An unpublished seroprevalence study in Tallaght University Hospital in west Dublin showed that 18% of hospital staff had positive antibodies to COVID-19 (10). Many HCWs in Ireland share accommodation, putting them at risk of acquiring

or transmitting infection in the home environment as well as the workplace. Understanding the transmission and potential immunity dynamics in HCW and in hospitals in Ireland remain key factors in controlling the pandemic at national level.

At the peak of the first wave of the COVID-19 pandemic in Ireland, Dublin was the area in Ireland that had the highest number of COVID-19 infections diagnosed. St. James' Hospital (SJH) is a large teaching hospital located in Dublin's south inner city with almost 4,700 employees. Nursing staff account for 38% of the workforce, followed by allied health care professionals and laboratory staff (16%), medical and dental staff (14%), administrative staff (14%), health care assistants (10%) and general support staff (8%). Seventy-seven percent of staff on site are female and 48% of staff are over the age of 40 years. Regarding nationality, 77% of staff are Irish, with Indian (7%) and Filipino (7%) being the next largest nationalities represented. From March-May 2020 9.6% of this workforce tested positive for SARS-CoV-2 infection via PCR, and by the start of October 10.2% of staff had tested positive by PCR, resulting in significant impact on staffing levels in the hospital; 42% of these infections were in nursing staff, 15% in healthcare assistants, 10% in doctors, 5% in health and social care workers, 6% in administration staff and 3% in general support staff.

Galway University Hospital (GUH) serves as both a regional hospital for Galway as well as being the tertiary referral centre for the SAOLTA hospital group. COVID-19 incident rates in the community in county Galway were significantly lower than that of the greater Dublin area during the first and second waves of the COVID-19 pandemic in Ireland (peaks in April and October 2020 respectively (4) (6)) and the regional seroprevalence was assumed to be similar to that of neighbouring Sligo area, where the national seroprevalence study was conducted (5). GUH has almost 4400 employees, composed of 15% administrative/management staff, 14% health and social care, 39% nursing staff, 5% general support staff, 7% other patient and client care and 20% medical/ dental staff. Seventy-six cases of COVID -19 were diagnosed by PCR and reported to occupational health during the first wave of the pandemic, corresponding to 1.8% of employees affected; 54% of these infections were in nursing staff and 25% in medical and dental staff. Only 3 further infections were identified up until the start of October 2020; 1.8% of all employees.

The study was planned at the end of the first wave of the pandemic in Ireland and was performed during the second wave. The national epidemiology remained similar in this second wave in terms of highest incidence in the greater Dublin area (4) (6).

This study aimed to perform antibody testing on all healthcare workers in these two hospitals to estimate the SARS-CoV-2 seroprevalence amongst a large cohort of HCWs working in acute sector hospitals in Ireland. We aimed to compare the prevalence of antibodies to SARS-CoV-2 across hospitals in two geographical areas with higher and lower community and hospital cumulative incidence of COVID-19 in Ireland, as defined at the time of commencing the study. We aimed to estimate the number of HCW that have had undiagnosed COVID-19 infection, and to improve understanding of HCW risk factors (demographic, living arrangements and work-place related risks) for SARS-CoV-2 infection, in order to inform health services preparedness for further waves of the pandemic.

Initial proposals for a second round seroprevalence survey, including longitudinal follow up of linked cases, after six months (PRECISE 2) to evaluate antibody decay have been revised to consider the roll out of vaccines directed against SARS-CoV-2. The study structure is well placed to assess serological and cellular indices of post vaccine immunity (38) (39).

Objectives

- To measure the prevalence of antibodies to SARS-CoV-2 in all HCWs in two hospitals in Ireland in areas of differing COVID-19 incidence
- To report the prevalence of antibodies to SARS-CoV-2 by sex, age group, ethnicity, nationality, area of work, type of patient exposure, previous symptoms, previous PCR testing, and living arrangements
- To examine the relationship between the presence of antibodies to SARS-CoV-2 and the self-reporting of symptoms consistent with COVID-19 or having a previous diagnosis of COVID-19 infection
- To repeat the study in April 2021 to assess changes in overall SARS-CoV-2 sero-prevalence, as well as changes in individual serostatus for those who participate both times.
- To assess indices of immunity and protection post vaccination

Methods

Participants and Processes

This is a longitudinal seroprevalence study, consisting of two sero-surveys six months apart, in October 2020 and in April 2021. This document pertains to the first seroprevalence study carried out from 14th-23rd October 2020. All staff members of both hospitals were invited to participate in an online self-administered consent and questionnaire in October 2020 followed by a blood test. Inclusion criteria was all staff members of both hospitals regardless of area of work. Those who were in quarantine or self-isolating during the dates of the blood sampling were excluded from participation. Students on attachment in the hospitals were also excluded from participation. Information about the study was disseminated from September 2020 onwards, via all-staff emails, text messages, hospital intranet, hospital meetings, heads of departments and discipline champions. Concerted efforts were made to directly target groups that are traditionally harder to access, who may not engage with hospital IT messaging services. We organised specific meetings with domestic staff, portering staff, security staff and HCAs. Similarly, our staff members are diverse ethnically, and speak many different languages. To overcome any potential language barrier all study information was translated into the five most commonly spoken languages in the hospitals. The study website contained information in all five languages, and hard copy posters and participant information leaflets were disseminated widely in the hospital in all five languages.

The online consent platform and questionnaire opened for participation on the 5th October until the end of the blood sampling period. Blood sampling took place simultaneously in both hospitals, from the 14thto the 23rd October. Following online consent, participants were asked for information about their demographics, role in the workplace, type of patient contact and whether they were also working in the hospital or any other nursing home from January -June 2020. Participants were defined as high risk if reporting daily contact with patients with known or suspected COVID-19 infection, intermediate-risk if reporting daily contact with patients without known or suspected COVID-19 infection and low-risk if reporting little or no patient contact. They were asked about personal previous confirmed infection, symptoms, close contact with a confirmed case of COVID-19 and previous testing because of this contact or for any other

reason. The questionnaire also elicited details of living arrangements; number of people in the household, and whether they live with other HCWs.

Participants were asked in the questionnaire whether they would like to receive the results of their antibody test. Results were issued by text message to those with a result of antibodies not detected. Those with a detected result were phoned by the study team to discuss the meaning of the result. A phone line was also available for those with a not detected result who wished to discuss their result.

Sample Testing

Samples were initially tested with the Abbott Architect SARS-CoV-2 immunoglobulin (Ig) G assay, directed against nucleocapsid protein as previously described (40) and as used for the SCOPI Study of community antibody prevalence in Ireland (5). An index value of ≥1.40 Sample/Calibrator (S/C) was considered positive, based on the manufacturers threshold for seropositivity at the time of testing (7) (8). Samples with an index value of 0.5-1.39 S/C were referred for additional testing, in line with the manufacturers' suggested grayzone at the time of testing (7). All positive and grayzone samples were sent to the National Virus Reference Laboratory (NVRL) for additional testing with the Wantai SARS-CoV-2 AB ELISA distributed by Fortress Diagnostics. Abbott assay positive results were considered positive, irrespective of the Wantai assay result, whereas Abbott assay grayzone results were considered positive only if antibody was also detected in the Wantai assay, During the testing process, newly published literature highlighted a potential decline in detection of antibodies with the Abbott Architect SARS-CoV-2 immunoglobulin (Ig) G assay after 60 days (41) (42). In response to this, in addition to having implemented Abbott's updated grayzone to improve assay sensitivity, it was decided to also test all samples with the Roche Elecsys anti-SARS-CoV-2 immunoassay, measuring antibodies to nucleocapsid protein, including IgG, to ensure adequate sensitivity based on evolving understanding of the various assays. A cutoff index (COI) of ≥1.0 in the Roche Elecsys anti-SARS-CoV-2 assay was considered positive, based on the manufacturer's threshold. (9). A positive result in the Abbott assay alone, or a grayzone result in the Abbott assay with a positive result in the Wantai assay, or a positive result in the Roche assay alone were each considered a positive result and qualitatively reported as antibody detected.

Ethical approval and Funding

Ethical approval was obtained from the National Research Ethics Committee (NREC) for COVID-19, Study Number 20-NREC. COV-101 (33). Funding was secured through the Health Service Executive (HSE) COVID-19 budget.

Statistical analysis

Frequencies and percentages were calculated for sociodemographic, epidemiological and clinical characteristics, including antibody results. Characteristics of those with a positive SARS-CoV-2 antibody result were compared to those with undetectable antibody, using the chi-square test. Univariate logistic regression was used to calculate relative risks (RR) along with their 95% confidence intervals to assess the association between detected SARS-CoV-2 antibody and characteristics of the study participants. Multivariable regression analysis was conducted to control for negative and positive confounding and to estimate adjusted relative risks (aRR) for key explanatory variables identified during the univariate analysis. Relevant variables reporting p-value <0.2 were considered for inclusion in the multivariable model. Forward stepwise variable selection was used, and the best fitting and most parsimonious model was selected based on the Akaike information criterion. Post-stratification weighting was explored to calculate overall seroprevalence and to account for different response rates in different HCWs roles groups. For the sake of parsimony, we report only unweighted results considering that we found no significant difference from the weighted versus un-weighted seroprevalence. Data management and statistical analysis was performed using Stata version 16 and R version 4.0.3 statistical software.

Results

Participation rates and demographics

All staff working in SJH and UHG (9,038 people) were invited to participate in the study. In total 5921 blood samples were collected representing a 66% (3115/4692) uptake in SJH and a 64% (2806/4395) uptake in UHG. Of all samples collected, 97% (5788/5921) of samples had a matching questionnaire completed, representing 65% (3042/4692) participation rate for both questionnaire and blood test in SJH and 63% (2745/4395) in UHG.

The socio-demographic characteristics of participants were similar in both hospitals. Seventy-seven percent were female, median age was 39.5 (IQR 30.4-48.9); 5.1% of participants were >60 years of age; 77% of participants were white Irish, 10% Asian (13% in SJH, 7% in UHG, p<.001), 9.5% were other white background (majority born in Poland, USA, and UK) and 2% were of African or any other black background. Eighty-eight percent of participants had third-level or postgraduate education; 91% of participants live with others, and 31% live with other HCWs. The majority (36%) of participants were nursing staff, followed by allied health care staff (19%), medical/dental staff (17%), administration staff (13%), general support staff (7.5%), health care assistants (HCA) (5%) and other (2%), broadly reflecting the HCW breakdown of the hospital staff (Table 1a). Participation rates among staff groupings were similar in both hospitals; nurses and health care assistants were slightly under-represented at 59% and 39% uptake respectively. In all other groups participation rate was above 60% (for detailed figures on participation see Table A-D, Annex).

Table 1a. Participant characteristics by hospital and total number of participants

Participant characteristics		St James's Hospital (N=3,042)		University Hospital Galway (N=2,745)		P-value*	Total (n=5,788)	
		n	%	n	%		N	%
Age groups	18-29	728	24	632	23	0.717	1,350	23
	30-39	831	27	785	29		1,617	28
	40-49	793	26	722	26		1,515	26
	50-59	532	18	468	17		1001	17
	Over 60	158	5.2	146	5.3		304	5.3
Sex	Female	2,326	77	2,152	78	0.117	4,478	77
	Male	716	24	592	22		1,308	23
	Other	-	-	-	-		-	-
	Missing	-	-	1	0.04		1	0.02
Ethnicity	Irish	2,262	74	2,182	80	<0.001	4,444	77
	Any other white background	267	8.8	284	10		551	10
	Any Asian background	393	13	184	7		577	10
	Any African or black background	65	2.1	48	1.8		113	2.0
	Other	55	1.8	46	1.7		101	1.8
	Missing	-	-	1	0.04		1	0.02
Country of birth*	Ireland	2,182	72	2,091	76	<0.001	4,273	74
	United Kingdom	152	5.0	192	7.0		344	5.9

	India	201	6.6	98	3.6		299	5.2
	Philippines	166	5.5	25	0.9		191	3.3
	Poland	24	0.8	48	1.8		72	1.2
	USA	22	0.7	38	1.4		60	1.0
	Other	295	9.7	253	9.2		548	9.5
	Missing	-	-	-	-		-	-
Education	Primary	27	0.9	2	0.1	<0.001	29	0.5
	Secondary	420	14	264	10		684	12
	Third level	1,300	43	1,245	45		2,545	44
	Post-graduate	1,295	43	1,232	45		2,527	44
	Missing	-	-	2	0.1		2	0.03
Role	Admin	454	15	349	13	<0.001	803	14
	Medical/dental	460	15	522	19		982	17
	Nursing/ midwifery	1045	34	1,019	37		2064	36
	Allied health	616	20	475	17		1012	19
	General support	255	8.4	179	6.5		434	7.5
	Health care assistant	157	5.2	129	4.7		286	4.9
	Other	55	1.8	72	2.6		127	2.2
	Missing	-	-	-	-		-	-
Lives with	Alone	256	8.4	223	8.1	0.020	479	8.3
	With others	2,768	91.0	2,518	91.7		5,286	91.3
	Missing	18	0.6	4	0.2		22	0.4
Lives with HCWs	Yes	928	31	839	31	0.983	1,767	31
	No	2,060	68	1,859	68		3,919	68
	Missing	54	1.8	47	1.7		101	1.8

* Calculated using the Chi-Square test

Previous exposure, symptoms and testing

In terms of previous exposure, 39% of participants in SJH had previously been a close contact of a confirmed case of COVID-19 infection, compared to only 19% of those in UHG. In both hospitals, 87% of these reported close contact events occurred at work. Seventeen percent of participants in SJH reported daily contact with confirmed cases of COVID-19 as part of their work; this was 14% of participants in UHG. A further 53% of the participating staff of SJH reported daily contact with patients without suspected or confirmed infection with COVID-19, compared to 60% in UHG. And 30% in SJH, 26% in UHG had little or no patient contact (Table 1b).

Symptoms consistent with COVID-19 had occurred in 55% of SJH staff and 45% of UHG staff. For a total of 50% of participants experiencing symptoms (in both hospitals) at some stage; 35%

of these were minor symptoms (equal to a cold or less), 9.1% had significant symptoms (comparable to a bad flu, bed-ridden) and 0.4% were hospitalized. These figures were similar in both sites (Table 1b).

In terms of self-reported previous testing, 55% of SJH staff and 40% of UHG staff had previously undergone PCR testing for infection with COVID-19. In SJH 9.6% of participants reported having previously tested positive by PCR compared to 2.7% of UHG participants (Table 1b).

Table 1b. COVID-19 related characteristics by hospital and total number of participants

Participant characteristics		St James's Hospital (N=3,042)		University Hospital Galway (N=2,745)		P -value*	Total (N=5,788)	
		n	%	n	%		n	%
Contact of a COVID-19 case	Yes	1,185	39	519	19	<0.001	1,704	30
	No	1,847	61	2,224	81		4,071	70
	Missing	10	0.3	2	0.1		12	0.2
Setting of close contact	Contact at work	1,039	88	456	88	0.916	1,495	88
	Contact outside of work	146	12	63	12		209	12
	Missing	-	-	-	-		-	-
Daily contact with COVID-19 patients	Contact with COVID-19 patients	510	17	392	14	<0.001	902	16
	Contact with patients without COVID-19	1,611	53	1,634	60		3,245	56
	No patient contact	918	30	717	26		1,635	28
	Missing	3	0.1	2	0.1		5	0.1
Previous COVID-19 symptoms	No symptoms	1,359	45	1,517	55	<0.001	2,876	50
	Had symptoms	1,683	55	1,228	45		2,911	50
	Missing	-	-	-	-		-	-
Severity	No symptoms	1,359	45	1,517	55	<0.001	2,876	50
	Minor symptoms	1,214	40	945	34		2,159	37
	Significant symptoms	442	15	259	9.4		701	12
	Hospitalised	27	0.9	24	0.9		51	0.9
	Missing	-	-				-	-
Previous COVID-19 PCR test	Yes	1,685	55	1,093	40	<0.001	2,778	48
	No	1,353	45	1,650	60		3,003	52
	Missing	4	0.1	2	0.1		6	0.1
Previous positive COVID-19 PCR test	Yes	292	9.6	75	2.7	<0.001	367	6.3
	No	2,746	90.3	2,668	97.2		5,414	93.6
	Missing	4	0.1	2	0.1		6	0.1

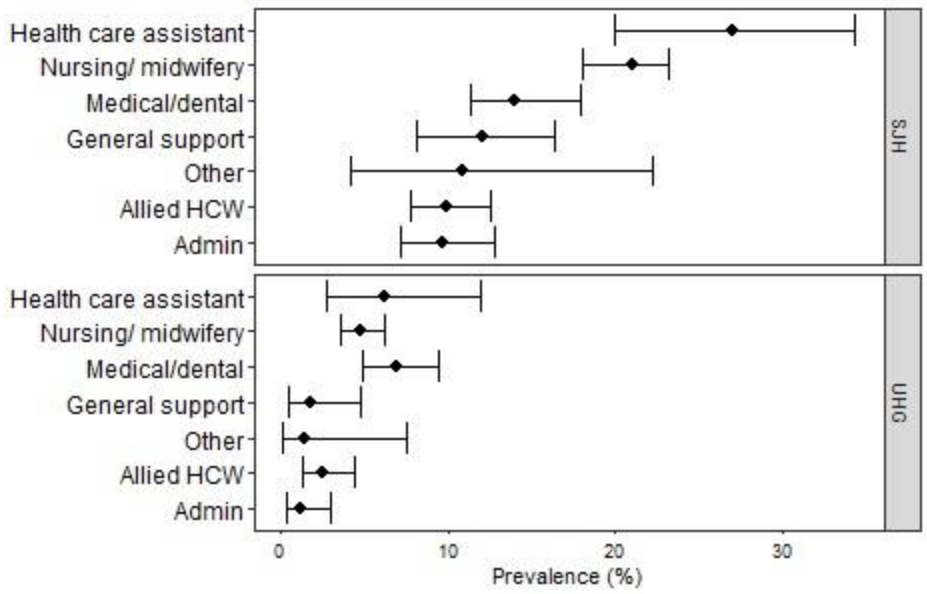
SARS-CoV-2 Seroprevalence by Site and by HCW role

In SJH, the overall SARS-CoV-2 seroprevalence was 15% (464/3042). It was 21% (108/510) in those who reported daily contact with known or suspected cases of COVID-19, 17% (269/1611) in those who reported daily contact with patients without known or suspected COVID-19 infection, and 9.5% (87/918) in those who reported little or no patient contact (Table 2d, appendix). Seroprevalence by professional subgroup was highest in HCAs at 27%, followed by nurses (21%), medical/ dental professionals (14%), general support staff (12%), allied healthcare professionals (11%) and administrative staff (9.5%), but confidence intervals overlap (Figure 1) (Table E Annex).

In UHG, the overall seroprevalence was 4.1%. It was 7.1% (28/392) in those who reported daily contact with known or suspected cases of COVID-19, 4.6% (75/1634) in those who reported daily contact with patients without known or suspected COVID-19 infection, and 1.3% (9/717) in those who reported little or no patient contact (Table 2f, appendix). Seroprevalence by professional subgroup was highest in medical/dental staff at 6.9 %, followed closely by HCAs (6.2%) and nurses (4.7%), but confidence intervals overlap (Figure 1) (Table F, Annex).

The combined data for both hospitals showed that HCAs were significantly more likely to be antibody positive with 18 % of those participating in the study having detectable antibodies. This was followed by nurses at 13% and medical/dental staff at 10%**.** The group with the lowest seroprevalence were the administration staff at 6% (Table G Annex).

Figure 1. Proportion of staff group with detectable antibodies to SARS-CoV-2, both hospitals, October 2020



SARS-CoV-2 antibody prevalence by history of previous PCR testing and symptoms

Ninety-five percent of those who reported a previous positive PCR had detectable antibody (350/367, 95.4%). The majority of those with previous positive PCR (358/367, 97.6%) had been symptomatic at the time of the positive PCR. There was no statistically significant difference between the proportion of antibody positive between those who were symptomatic at the time of positive PCR, 95.6% (325/340), and those who were not symptomatic 92.0% (23/25).

Sixteen percent (90/576) of the participants who had a detectable antibody reported never having had symptoms consistent with COVID-19 infection at any stage (Table H, annex).

Eight-hundred participants reported that they had experienced symptoms at some stage but had never been tested by PCR for COVID-19 infection. Forty-three of these participants (5%) had a detectable antibody, meaning that these people possibly continued to work while having symptoms and not seeking a test for COVID-19. Nine of these participants who had never been tested and had detectable antibody reported significant COVID-19 like symptoms at some stage.

Undiagnosed infections

In total, 576 participants (464 in SJH and 112 in UHG) had detectable antibodies. Of these, 226/576 (39%) had never been diagnosed with COVID-19 infection. This represented at least 3.9% of the total study population having a previously undiagnosed infection. The majority of those who had never been diagnosed (141/226 (62%)) had experienced COVID-19 like symptoms at some stage, and 37/141 (26%) of those with symptoms reported that they had experienced significant symptoms. Despite this, 101/226 of these participants who were antibody positive but had never been diagnosed had never undergone PCR testing at any stage. The majority of these undiagnosed infections were in SJH employees (187/226, 83%), and most (169/187, 90%) had worked in SJH throughout the pandemic. Most of the participants with undiagnosed infections reported daily patient contact in their role (188/226, 83%); 89/226 (40%) were nurses and 33/226 (14%) were doctors.

Risk factors for antibody positivity

Characteristics of those participants who were antibody positive compared with those who were antibody negative for both hospitals combined are shown in Tables 2. Those of male sex, and those in the 18-29-year age group had a higher seroprevalence; 12% of all participating males had detectable antibody versus 9.4% of females (p=.013), and 13% of all participants aged 18-29 had detectable antibodies (p<.001). Regarding ethnicity 19% of Asian participants and 14% of participants of African or other black background were seropositive, versus 8.6% of white Irish participants (p<.001). Detectable antibody was found in 18% of HCAs, 13% of nurses, 10% of doctors, 7.6% of general support staff, 6.7% of allied health professionals and 6.0% of administration staff (p<.001). Ten percent of those living with others had detectable antibody compared to 5.9% of those living alone (p=.007), and 13% of those living with other HCWs had detectable antibodies compared with 8.5% of those not living with HCWs (p<.001). Those with daily exposure to patients with confirmed or suspected COVID-19 infection had a seropositivity of 15%, compared to 11% in those with daily contact with patients without confirmed or suspected COVID-19 infection, and 5.9% of those with little or no patient contact (p<.001). Nineteen percent of those who reported at least one close contact with a confirmed case had detectable antibody, compared to 6.1% of those who had never had a close contact event (p<.001); 27% of those in whom the contact was in the community or household had detectable

antibody, versus 18% of those in whom the close contact event was in the workplace (p=.002) (Table 2a and 2b).

The characteristics of those participants who were antibody positive in each hospital are shown in Tables 2c-2f (annex). The main differences in these characteristics between the two hospitals were in sex and working role. There was a strong association with being antibody positive if male in UHG (6.3% of males versus 3.5% of females seropositive, p<.003), but the difference between seropositivity in males and females in SJH was less pronouced (Tables 2c and 2e, annex). The differences in breakdown by working role is described above. Regarding living arrangements, in SJH the association between living arrangements and seropositivity was much stronger than in UHG; SJH participants living with others had double the seroprevalence than those living alone (16% versus 8%, p<.004) and 21% of those living with other HCWs were antibody positive compared to 13% of those living with non-HCW, p<.001). The data for UHG shows a similar trend, but with a lower overall prevalence (Tables 2d and 2f, annex).

On multivariable analysis of the combined hospital data, the adjusted relative risk of detectable antibody was higher for the following characteristics: working in SJH as opposed to UHG (aRR 3.7, 95% CI 3.0-4.5. p<.001), being a healthcare assistant (aRR 2.0, 95% CI 1.4 – 3.0, p 0.001), nurse (aRR 1.6, 95% CI 1.1 – 2.2, p 0.007), daily exposure to patients with confirmed or suspected COVID-19 infection (aRR 1.6, 95% CI 1.2-2.1, p 0.002), daily contact with patients not known or suspected to have COVID-19 infection (aRR 1.4, 95% CI 1.1-1.8, p 0.008), age 18-29 (aRR 1.4, 95% CI 1.1-1.9, p 0.006), living with others (aRR 1.5, 95% CI 1.0-2.1, p 0.048), living with other HCW (aRR 1.3, 95% CI 1.1 – 1.5, p 0.007), being of Asian background (aRR 1.3, 95% CI 1.0-1.6, p 0.028) and male sex (aRR 1.2, 95% CI 1.0-1.4, p = 0.046). (Table 3).

On multivariable analysis by hospital, in SJH the aRR of detectable antibody was statistically significant for the following characteristics: being a HCA (aRR 1.0, 95% CI 1.3-3.0, p=.002), being a nurse (aRR 1.6, 95% CI 1.1-2.2, p=.013), living with others (aRR 1.6, 95% CI 1.0-2.4, p=.037), living with other HCWs (aRR 1.3, 95% CI 1.1-1.6, p=.003), daily contact with patients with known or suspected COVID-19 infection (aRR 1.4, 95% CI 1.0-1.9, p=.036), daily contact with patients without known or suspected COVID-19 infection (aRR 1.3, 95% CI 1.0-1.7, p=.0398), and being aged 18-29 (aRR 1.3, 95% CI 1.0-1.8, p=.029) (Table 3a, annex).

In UHG the aRR of detectable antibody was statistically significant for the following characteristics: age 30-39 (aRR 3.5, 95% CI 1.6-7.6, p=.002), daily contact with patients with known or suspected COVID-19 infection (aRR 3.1, 95% CI 1.3-6.9, p=.009) and male sex (aRR 1.9, 95% CI 1.2-3.0, p=.005). (Tables 3b, annex).

Table 2a. Prevalence of SARS-CoV-2 antibodies by participant characteristics, both hospitals

Participant characteristics		Total N	SARS-CoV-2 Ab detected n	% (95% CI)	P-value*
Age groups	18-29	1,350	177	13 (11 – 15)	
	30-39	1,617	168	10 (8.9 - 12)	<0.001
	40-49	1,515	124	8.2 (6.9 – 9.7)	
	50-59	1,001	77	7.7 (6.1 – 9.5)	
	Over 60	304	30	9.9 (6.8 – 14)	
Sex	Female	4,478	422	9.4 (8.6 – 10)	
	Male	1,308	154	12 (10 - 14)	0.013
Ethnicity	Irish	4,444	384	8.6 (7.8 – 9.5)	
	Any other white background	551	62	11 (8.7 – 14.2)	<0.001
	African and any other black background	113	16	14 (8.3 - 22)	
	Asian background	577	107	19 (16 - 22)	
	Other	101	7	6.9 (2.6 - 15)	
Country of birth*	Ireland	4,273	373	8.7 (7.9 – 9.6)	
	United Kingdom	344	32	9.3 (6.5 - 13)	
	India	299	54	18 (14 - 31)	
	Philippines	191	47	25 (19 - 31)	<0.001
	Poland	72	10	14 (6.9 -24)	
	USA	60	3	5.0 (1.0 - 14)	
	Other	548	57	10 (8.0 - 13)	
Education	Primary	29	4	14 (3.9 - 32)	
	Secondary	684	61	8.9 (6.9 - 11)	0.055
	Third level	2,545	283	11 (9.9 - 12)	
	Post-graduate	2,527	228	9.0 (7.9 - 10)	
Role	Admin	803	48	6.0 (4.4 – 7.9)	
	Medical/dental	982	102	10 (8.6 - 13)	
	Nursing/ midwifery	2,064	263	13 (11 -14)	
	Allied health	1,091	73	6.7 (5.3 -8.3)	<0.001
	General support	434	33	7.6 (5.3 - 11)	
	Health care assistant	286	50	18 (13 - 22)	
	Other	127	7	5.5 (2.2 - 11)	
Lives with	Alone	479	28	5.9 (3.9 – 8.3)	
	With others	5,286	546	10 (9.5 - 11)	0.007
	Missing	22	2	9.1 (1.1 - 29)	
Lives with HCWs	Yes	1,767	234	13 (12 - 15)	
	No	3,919	332	8.5 (7.6 -9.4)	<0.001
	Missing	101	10	9.9 (4.9 -18)	

* Calculated using the Chi-Square test

Table 2b. Prevalence of SARS-CoV-2 antibodies by COVID-19 related characteristics, both hospitals

Participant characteristics		Total N	SARS-CoV-2 Ab detected n	% (95% CI)	P-value*
Contact of a COVID-19 case	Yes	1,704	325	19 (17 - 21)	<0.001
	No	4068	249	6.1 (5.4 -6.9)	
	Missing	10	2	0.2 (0.2-0.5)	
Setting of close contact	Contact at work	1,495	269	18 (16 - 20)	0.002
	Contact outside of work	209	56	27 (21 - 33)	
Workplace exposure	Daily contact with COVID-19 patients	902	136	15 (13 - 18)	<0.001
	Daily contact with patients without COVID	3,245	344	11 (9.6 - 12)	
	No patients contact	1,635	96	5.9 (4.9 – 7.1)	
Previous COVID-19 like symptoms	No symptoms	2,876	92	3.2 (2.6 – 3.9)	<0.001
	Had symptoms	2,911	484	17 (15 - 18)	
Previous COVID-19 PCR test	Yes	2,778	474	17 (16 - 19)	<0.001
	No	3,003	102	3.4 (2.8 – 4.1)	
Previous positive COVID-19 PCR test	Yes	367	350	95.4 (92.7 – 97.3)	<0.001
	No	5,414	226	4.2 (3.7 – 4.7)	

* Calculated using the Chi-Square test

Table 3. Association between risk factors and the presence of SARS-CoV-2 antibodies, both hospitals

Participant characteristics		Unadjusted relative risk (95% CI)	P-value	Adjusted relative risk (95% CI)	P-value
Hospital	Galway	Ref.			
	St. James's	3.7 (3.1 – 4.6)	<0.001	3.7 (3.0 - 4.5)	<0.001
Age groups	18-29	1.7 (1.3 – 2.2)	<0.001	1.4 (1.1 – 1.9)	0.006
	30-39	1.4 (1.1 - 1.8)	0.022	1.2 (0.9 – 1.5)	0.217
	40-49	1.1 (0.8 - 1.4)	0.656	1.0 (0.8 – 1.3)	0.978
	50-59	Ref.			
	Over 60	1.3 (0.9 -1.9)	0.224	1.4 (0.9 – 2.0)	0.112
Sex	Female	Ref.			
	Male	1.3 (1.1 – 1.5)	0.012	1.2 (1.0 – 1.4)	0.046
Ethnicity	Irish	Ref.			
	Any other white background	1.3 (1.0 – 1.7)	0.041	1.3 (1.0 - 1.6)	0.068
	African and other black background	1.6 (1.0 – 2.7)	0.037	1.3 (0.8 – 2.0)	0.299
	Asian background	2.2 (1.8 – 2.6)	<0.001	1.3 (1.0 – 1.6)	0.028
	Other	0.8 (0.4 -1.7)	0.549	0.6 (0.2 – 1.3)	0.177
Country of birth	Ireland	Ref.			Did not enter
	India	2.1 (1.6 – 2.7)	<0.001		
	Philippines	2.8 (2.2 – 3.7)	<0.001		
	United Kingdom	1.1 (0.8 – 1.5)	0.717		
	Poland	1.6 (0.9 – 2.9)	0.119		
	USA	0.6 (0.2 -1.7)	0.324		
	Other	1.2 (0.9 – 1. 6)	0.193		
Education	Primary	1.5 (0.6 – 3.8)	0.365		Did not enter
	Secondary	1.0 (0.8 – 1.3)	0.933		
	Third level	1.2 (1.0 - 1.5)	0.013		
	Post-graduate	Ref.			
Role	Admin	Ref.			
	Doctor\Dental	1.7 (1.3 - 2.4)	0.001	1.2 (0.8 – 1.7)	0.327
	Nursing	2.1 (1.6 – 2.9)	<0.001	1.6 (1.1 – 2.2)	0.007
	HCA	2.9 (2.0 – 4.2)	<0.001	2.0 (1.4 – 3.0)	0.001
	General support	1.3 (0.8 - 2.0)	0.270	0.9 (0.6 – 1.4)	0.687
	Allied HCWs	1.1 (0.8 – 1.6)	0.531	0.9 (0.6 – 1.3)	0.635
	Other	0.9 (0.4 – 2.0)	0.837	1.0 (0.5 – 2.1)	0.941
Lives with	Alone	Ref.			

	With others	1.8 (1.2 – 2.6)	0.002	1.5 (1.0 – 2.1)	0.048
Lives with HCWs	No	Ref.			
	Yes	1.6 (1.4 -1.8)	<0.001	1.3 (1.1 – 1.5)	0.007
Contact of a COVID-19 case	No	Ref.			Did not enter
	Yes	3.1 (2.7 – 3.6)	<0.001		
Close contact at work **	No	1.5 (1.2 – 1.9)	0.002		Did not enter
	Yes	Ref.			
Workplace exposure to COVID-19 patients	No patients contact	Ref.			
	Daily contact with patients without COVID	1.8 (1.5 – 2.3)	<0.001	1.4 (1.1 – 1.8)	0.008
	Daily contact with COVID-19 patients	2.6 (2.0 – 3.3)	<0.001	1.6 (1.2 – 2.1)	0.002
Previous COVID-19 like symptoms	No	Ref.			Did not enter
	Yes	5.2 (4.2 – 6.5)	<0.001		

**Calculated for close contacts of COVID-19 cases only (n=1,704)

Discussion

This was a national SARS-CoV-2 seroprevalence study of HCWs in two hospitals in Ireland with diverging community and healthcare rates of infection. Our findings showed that differing seroprevalence in the two hospitals reflected the difference in the respective community seroprevalence (5). We found higher SARS-CoV-2 antibody prevalence in SJH in south inner-city Dublin (15%) than in UHG, Galway (4.1%). We identified risk factors for antibody positivity: staff members working closely with patients with known or suspected COVID-19 infection and living with others, and in particular living with other HCWs, were a risk factor for seropositivity. Furthermore, HCAs and nurses were at a higher risk.

Overall seroprevalence

Our participants were similar in age and sex to those in other European studies (14) (29) (24). The seroprevalence between SJH and UHG differed by four-fold, reflecting the difference in seroprevalence in the community in the two geo-locations in June 2020 (5). The seroprevalence in SJH was similar to that found in a recent study in Tallaght University Hospital (10), also in Dublin, suggesting community incidence as the main risk factor for acquisition of COVID-19 infection in HCW. The seroprevalence in both hospitals fell within the wide range previously described in other studies (13) (14) (31) (32) (33) (24), and fell either side of the European estimate of 8.5% found by a meta-analysis published in November 2020 (11). The seroprevalence in the hospital setting was six times the community seroprevalence found in the SCOPI study, performed four months earlier, for both geo-areas of higher and lower community seroprevalence (5). This difference is unlikely to be due to new infections acquired during that time frame given the low community incidence during those months. The increased risk was across all HCW, including those with no direct patient contact. Similar studies have found even bigger differences between hospital and community seroprevalence; the Greek study found HCW seroprevalence between 10-22 times higher than the general population (24). It should be noted that this seroprevalence study was performed during the second wave of the pandemic in Ireland, and therefore will not account for the dramatic increase in incidence since the middle of December, in the third wave of the pandemic.

Seroprevalence by role and type of patient contact

The higher seroprevalence and higher RR amongst HCAs and nurses factors reflects the degree of proximity to patients that is required by the role- a recognized risk factor for disease acquisition (12) (23). In UHG the seroprevalence was highest amongst doctors. Though this difference was not statistically significant, it may be accounted for, at least in part, by the fact that many doctors move hospital frequently (at least annually, and some after 3-6 months). It is possible that some of the doctors contributing to this higher seroprevalence had acquired infection during work in other hospitals in areas of higher incidence prior to moving to UHG. The seroprevalence amongst nurses in SJH was 21%, which is very similar to the seroprevalence found amongst the nursing staff in the study conducted in Tallaght Hospital (10). The seroprevalence and aRR were higher in the high-risk group in our study (those with daily contact with patients with known or suspected COVID-19 disease), followed by the intermediate risk group. Studies have differed on this result; a German study showed a higher seroprevalence among the intermediate risk group with comparison to the high-risk group, potentially due to less scrupulous adherence to infection control precautions including use of personal protective equipment (PPE) on the non-COVID wards (13), and a large Spanish study found no significant correlation between role or direct patient contact and antibody positivity, though community incidence was higher in their setting (14).

Previous symptoms and testing

In both hospitals, the seroprevalence was higher than the PCR proven diagnoses of COVID-19 infection (15% vs 10.2% in SJH, and 4.1% vs 1.8% in UGH (43)) and higher than the self-reported previous confirmed diagnoses (15% vs 9.6% in SJH and 4.1% versus 2.7% in UHG). In our study 39% of infections were undiagnosed, and 16% of those with positive antibodies reported that they had not experienced symptoms at any stage. Therefore, it is likely that these HCWs were working during the infectious period, with potential for onwards transmission to both patients and other staff, as well as to household members. While the proper use of PPE reduces this risk in the hospital setting, the risk of onwards transmission in the household remains high, as well as in interactions in the hospital with both patients and staff where PPE and IPC measures are not fully adhered to. This is especially true for undiagnosed symptomatic infections, which have higher rates of onwards transmission (15). The majority of these HCW reported symptoms at some stage, though we do not know if the reported symptoms coincided

with the time of the undiagnosed infection. This highlights the importance of early detection and reinforces the necessity for universal adherence to standard infection control precautions at all times, compliance with transmission-based precautions and appropriate use of PPE including face masks in the hospital setting(16). These findings support the current national recommendation to undertake asymptomatic HCWs screening on detection of a hospital-acquired case of COVID-19 (17). Considering these findings, regular screening of asymptomatic HCWs beyond this setting may also be considered, particularly in areas or times of higher community incidence (18) (19), although the impact or the frequency of serial testing required to have a significant impact on HCW-HCW or HCW-patient transmission, has not been established. (20) (21) (22).

Other studies have also shown that symptomatic individuals were more likely to be antibody positive than asymptomatic individuals (30). In our study there was no significant difference in the proportion of those who were antibody positive when comparing those who had previous positive PCR with symptoms and those who had previous positive PCR without symptoms, although this may be due to small numbers in the asymptomatic group.

Eight-hundred participants reported that they had experienced symptoms at some stage but had never been tested by PCR for COVID-19 infection. Forty-three of these participants (5%) had a detectable antibody, which means that these people possibly continued to work while having symptoms and not seeking a test for COVID-19. Although this proportion of infections is smaller than that of the asymptomatic infections, it calls for enhanced messaging to all HCWs about the importance of self-isolating when presenting with any symptoms consistent with COVID-19 infection and the need to make testing easily accessible to HCW, even when symptoms are mild. This is likely to remain true after completion of vaccination in HCWs who are eligible, as current evidence suggests that while vaccination leads to decreased severity of infection (44), the degree to which vaccination will decrease onwards transmission is still not clear, hence early case diagnosis will remain important to stop spread in the hospital setting.

Characteristics of and risk factors for antibody positivity

The main risk factors identified to be statistically significantly associated with antibody positivity (in decreasing order of RR) were working in SJH versus UHG, being a HCA or nurse, daily contact with patients (especially those known or suspected to have COVID-19 infection), age 18-29, living with others, in particular living with other HCWs, being of Asian background, and being male. Some of these risk factors have also been identified in other studies, including the meta-analysis of European studies (11) (23) (45). In our study, the association between antibody positivity and male sex was only found in the Galway setting. This risk was independent of all other characteristics included in the study, and therefore is likely to be due to social circumstances that were not examined. In our setting, many non-Irish HCWs live together, which was accounted for in the adjusted risk. However, it is possible that there are other social factors relating to ethnicity that were not evaluated in our study and that are contributing to this risk seen amongst those of Asian background, which was true in both settings. To the best of our knowledge no other study has identified HCAs in particular as being at risk; on multivariable analysis in our study being a HCA carried the highest adjusted relative risk of antibody positivity, which reflects the work done by a HCA in our setting, which involves constant close patient contact. This role may differ in other settings.

In our study, having daily contact with COVID-19 patients had a stronger association with being antibody positive than living with others. These findings are in agreement with the study by Lai Y et al. which found that contact with patients was responsible for 59% of infections in HCWs, colleagues with infection accounted for 11%, and community acquired infections accounted for 13% of infections in HCWs (12). These findings must be interpreted considering the variation in the intensity of community transmission, and the varying amount of testing being performed in the two communities. We did find, however, that although most reported known close contact events occurred in the work setting, those who had a close contact in the community or household were more likely to be antibody positive than those whose close contact occurred in the hospital setting, assumably because standard and transmission-based precautions including the use of PPE are not generally practiced, or practiced consistently, in the household or community setting, and the potentially ongoing nature of the close contact event in a household. Other seroprevalence studies among HCWs have found some correlation between antibody positivity and size of household (14), and having a household contact (25).To the best of our knowledge ours is the first hospital based seroprevalence study to identify living with other

HCWs as a risk for being SARS-CoV-2 antibody positive. Our findings suggest that a proportion of the HCWs contracting COVID-19 are doing so in their home environment. This was mainly true of the Dublin setting, potentially due to rental prices and overcrowded accommodation. As mentioned above, the current higher level of community transmission is likely to increase the proportion of infections acquired in the community or household.

While recent studies have highlighted the protective nature of SARS-CoV-2 antibodies against recurrent symptomatic infection for at least 6 months (46) , no recommendations can be made on an individual level for those participants with positive antibodies given the lack of certainty as to when the antibody was acquired, as well as the fact that even asymptomatic recurrence could lead to onwards transmission in the hospital setting. Staff in all hospitals should continue to follow all public health guidelines for infection prevention and control regardless of antibody status.

Limitations

Our study has several limitations. Firstly, information on COVID-19 symptoms and test results were self-reported and thus could be biased. Secondly, although the uptake rate of 64% overall is good for an opt-in study, there may be a selection bias; it is possible that those who chose not to take part did so due to busier workload, eg. those working on a COVID-19 ward, and therefore with a higher risk of COVID-19 infection. Thirdly, one of the main reasons for overall good recruitment was the incentive of each participant receiving their individual result. This too may introduce a selection bias; those who already know that they have had COVID-19 infection may have been less interested in participating, as well as those who may have already had private antibody testing done elsewhere, which could lead to an under-estimate in the true seroprevalence. Conversely, those who had a previously confirmed infection by PCR may have had more interest in participating to see if they had gained antibodies (and potential protection). Fourthly, the non-phlebotomy part of the study was conducted online, with an online consent process, an online questionnaire, and an online booking system for the blood test. This risks exclusion of those who are less literate in information technology (IT). This, however, was identified as a potential limitation from the start, and attempts were made to mitigate this selection bias. Groups were identified as potentially at risk of exclusion on this basis and were

targeted directly for inclusion in the study, with small-group sessions to aid consent and questionnaire completion and walk-in clinics for phlebotomy. In the fourth instance, although the communication strategy was an important part of the recruitment process, the study took part during our second wave of the pandemic, and therefore also relied heavily on engagement with IT platforms (email, messenger groups, hospital intranet) and less on face-to-face announcements which may have captured the harder to reach groups. We did attempt to mitigate this with specific meetings with key groups and stakeholders, as well as multilanguage information. In the fifth instance, in testing on two different platforms, we chose to prioritise sensitivity over specificity. However, the rate of discordant results was low, and unlikely to have had a significant effect on the data. And finally, even though the sample size was large, some covariate partners were small and provide limited information.

Conclusion and Recommendations

The overall seroprevalence of antibodies to COVID-19 was 15% in SJH and 4.1% in UHG, reflecting the difference in community transmission and diagnosed disease incidence in each geographical area and each hospital during the first wave of the pandemic, and suggesting that the main risk factor for acquisition of COVID-19 infection in HCW is the local community incidence. The risk was across all HCWs. Specific risk factors for antibody positivity included being a HCA or nurse, daily contact with patients (especially those known or suspected to have COVID-19 infection), age 18-29, living with others, in particular living with other HCWs, being of Asian background, and being male. Thirty-nine percent of infections had been undiagnosed, and at least 16% of infections were asymptomatic, which highlights the need for early detection, universal adherence to standard infection control precautions, appropriate compliance with transmission-based precautions and ongoing universal use of face masks for all person-encounters in the hospital setting. Considering these findings, the importance of screening asymptomatic HCWs as part of management of hospital-acquired cases and outbreaks of infection is highlighted. Consideration could be given to the potential role for regular screening of asymptomatic HCWs in certain settings, or at times of higher rates of community transmission, although the frequency of testing that would be required to have significant impact on transmission of infection from HCWs is not established. Forty-three participants with detectable antibodies had been symptomatic at some stage but never underwent PCR testing.

This highlights the need for ongoing messaging to HCWs about the necessity of self-isolation and the need for testing to be easily accessible to HCW, even when symptoms are mild.

This national study supports the findings of other international studies in terms of these risk factors, and highlights the varying epidemiology in similarly sized hospitals in locations of diverging community incidence. It is the first study, to the best of our knowledge, to specifically delineate the relationship between living with other HCWs and risk of antibody positivity, and close contact events in the household or community had a stronger association with antibody positivity than close contact events in the workplace.

This study is paramount in improving understanding of transmission dynamics, HCW risk factors (demographic, workplace- and household-related) and potential HCW immunity (as well as waning immunity) in hospitals in Ireland. As the national COVID-19 vaccination programme is rolled out, this study will be crucial to inform vaccination strategy in hospitals in Ireland. The higher risk in all categories of HCW should be recognised. It will also be important for future COVID-19 vaccine effectiveness studies in HCWs. While the hope is that the vaccine will change this epidemiology, we will most likely still need to have readily available HCW testing even after completion of vaccination. Finally, bearing in mind the differing results between these two hospitals, these results and resulting recommendations may be used to inform future public health responses at local and national level in other similar institutions.

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Annex

Table A. Response rate by HCW type

HCW role	St James's Hospital Response Rate			University Hospital Galway Response Rate			Combined Response Rate		
	N	n	%	N	n	%	N	n	%
Admin	693	454	66%	639	349	55%	1,332	803	60%
Medical/dental	621	460	74%	814	522	64%	1,435	982	68%
Nursing/ midwifery	1,802	1,045	58%	1,689	1,019	60%	3,491	2,064	59%
Allied health	742	616	83%	648	475	73%	1,390	1,091	78%
General support	412	255	62%	240	179	75%	652	434	67%
Health care assistant	422	157	37%	316	129	41%	738	286	39%
Other	-	55		-	72		-	127	
Total	4,692	3042	65%	4,346	2,745	63%	9,038	5,788	64%

Table B. Comparison of all staff and study participants in St James's Hospital by healthcare worker role

HCW role	St James's Hospital all staff		St James's Hospital study participants		Difference	
	N	%	N	%	N	%
Admin	693	15	454	15	239	0.1
Medical/dental	621	13	460	15	161	1.9
Nursing/ midwifery	1,802	38	1,045	35	757	-3.8
Allied health	742	16	616	20	126	4.5
General support	412	8.8	255	8.4	157	-0.4
Health care assistant	422	9.0	157	5.2	265	-3.8
Other	-	-	55	1.8	-	-
Total	4,692	100	3042	100	1650	-

Table C. Comparison of all staff and study participant in University Hospital Galway by healthcare worker role

HCW role	University Hospital Galway all staff		University Hospital Galway study participants		Difference	
	N	%	N	%	N	%
Admin	639	15	349	13	290	-2

Medical/dental	814	19	522	19	291	0.4
Nursing/ midwifery	1,689	39	1,019	37	670	-1.8
Allied health	648	15	475	17	173	2.4
General support	240	5.5	179	6.5	61	1
Health care assistant	316	7.3	129	4.7	187	-2.6
Other	-	-	72	2.6	-	-
Total	4,346	100	2,745	100	1600	-

Table D. Comparison of all staff and study participants by healthcare worker role

HCW role	All invited staff		All study participants		Difference	
	N	%	N	%	N	%
Admin	1,332	15	803	13	529	-1.3
Medical/dental	1,435	16	982	17	452	1.1
Nursing/ midwifery	3,491	39	2,064	36	1427	-2.9
Allied health	1,390	15	1,091	19	299	3.2
General support	652	7.2	434	7.5	218	0.3
Health care assistant	738	8.2	286	4.9	452	-3.3
Other	-	-	127	2.19	-	-
Total	9,038	100	5,788	100	3250	

Table E. SARS-CoV-2 Seroprevalence by healthcare worker role in SJH, October 2020

HCW role	Participated SJH		Positive Results SJH			P-value*
	N	% of group	N	% of tested	95% Confidence Intervals (%)	
Admin	454	66	44	9.7	7.1-13	
Medical/dental	460	74	66	14	11-18	
Nursing/ midwifery	1,045	58	215	21	18-23	
Allied health	616	83	61	9.9	7.7-13	<.001
General support	255	62	30	12	8.1-16	
Health care assistant	157	37	42	27	20-34	
Other	55		6	11	4.1-22	
Total	3042	65	466	15	14-16	

*Calculated using the Chi-Square test

Table F. SARS-CoV-2 Seroprevalence by healthcare worker role in UHG, October 2020

HCW role	Participated UHG		Positive Results UHG			P-value*
	N	% of group	N	% of tested	95% Confidence Intervals (%)	
Admin	349	55	4	1.2	0.3-2.9	<.001
Medical/dental	522	64	36	6.9	4.9-9.4	
Nursing/ midwifery	1,019	60	48	4.7	3.5-6.2	
Allied health	475	73	12	2.5	1.3-4.4	
General support	179	75	3	1.7	0.4-4.8	
Health care assistant	129	41	8	6.2	2.7-12	
Other	72		1	1.4	0.1-7.5	
Total	2,745	63	112	4.1	3.4-4.9	

* Calculated using the Chi-Square test

Table G. Seroprevalence by healthcare worker role, both hospitals, October 2020

HCW role	Participated		Positive Results			P-value*
	N	% of group	N	% of tested	95% Confidence Intervals (%)	
Admin	803	60	48	6.0	4.4-7.9	<.001
Medical/dental	982	68	102	10	8.5-13	
Nursing/ midwifery	2,064	59	263	13	11-14	
Allied health	1,091	78	73	6.7	5.3-8.4	
General support	434	67	33	7.6	5.3-11	
Health care assistant	286	39	50	18	13-22	
Other	127	-	7	5.5	2.2-11	
Total	5,788	64	576	10	9.2-11	

* Calculated using the Chi-Square test

Characteristics of HCWs with SARS-CoV-2 antibodies detected

The HCWs with detectable SARS-CoV-2 antibodies had a median age of 36.7 (IQR 28.6-46.9) and were 73% female, 67% Irish and 21.4% BAME. 46% were nurses, and 89% had at least third level education. Of them, 95% were living with other people, and 41% were living with other HCWs. 16% had not experienced symptoms consistent with COVID-19 at any stage. 82% had previously had at least one PCR test for COVID-19, and 61% had previously had a positive test. (Table H).

Table H. Characteristics of the HCWs with SARS-CoV-2 antibodies detected (n=576), by hospital

Participant characteristics		St James's Hospital (n=464)		University Hospital Galway (n=112)		All with SARS-CoV-2 IgG antibodies detected (n=576)	
Age	Median age (IQR)	37	29-48	36	29-42	37	29-47
		N	**%**	**N**	**%**	**N**	**%**
Age groups	18-29	148	32	29	26	177	31
	30-39	121	26	47	42	168	29
	40-49	99	21	25	22	124	32
	50-59	70	15	7	6.3	77	13
	Over 60	26	5.6	4	3.6	30	5.2
Sex	Female	347	75	75	67	422	73
	Male	117	25	37	33	154	27
Ethnicity	Irish	305	66	80	71	385	67
	Any other white background	44	9.5	18	16	62	11
	Any Asian background	94	20	13	12	107	19
	African or other black background	15	3.2	1	0.9	16	2.8
	Other	6	1.3	-	-	6	1.0
Country of birth*	Ireland	291	63	82	73	373	65
	United Kingdom	25	5.4	7	6.3	32	5.6
	India	46	9.9	8	7.1	54	9.4
	Philippines	45	9.7	2	1.8	47	8.2
	Poland	7	1.5	3	2.7	10	1.7
	USA	3	0.7	-	-	3	0.5
	Other	47	10	10	8.9	57	9.9
Education	Primary	4	0.9	-	-	4	0.7
	Secondary	53	11	8	7.1	61	11
	Third level	229	49	54	48	283	49
	Post-graduate	178	38	50	45	228	40
Role	Admin	44	9.5	4	3.6	48	8.3
	Medical/dental	66	14	36	32	102	18
	Nursing/ midwifery	215	46	48	43	263	46
	Allied health	61	13	12	11	73	13
	General support	30	6.5	3	2.7	33	5.7
	Health care assistant	42	9.1	8	7.1	50	8.7
	Other	6	1.3	1	0.9	7	1.2
Lives with	Alone	21	4.5	7	6.3	28	4.9
	With others	441	95.0	105	93.8	546	94.8
	Missing	2	0.4	-	-	2	0.3
Lives with HCWs	Yes	193	42	40	37	234	41
	No	262	57	70	63	332	58
	Missing	9	1.9	1	0.9	10	1.7
Previous COVID-19 like symptoms	No symptoms	70	15	20	18	90	16
	Had symptoms	392	85	92	82	484	84
	Missing	2	0.4	-	-	2	0.4

Previous COVID-19 PCR test	Yes	385	83	89	80	474	82
	No	79	17	23	21	102	18
Previous positive COVID-19 PCR test	Yes	277	60	73	65	350	61
	No	187	40	39	35	226	39

Table 2c. Prevalence of SARS-CoV-2 antibodies by participant characteristics, St James's Hospital

Participant characteristics		Total	SARS-CoV-2 IgG detected		P-value*
		N	n	% (95% CI)	
Age groups	18-29	728	148	20 (17 - 23)	<0.001
	30-39	831	121	15 (12 -17)	
	40-49	793	99	13 (10 -15)	
	50-59	532	70	13 (10 - 16)	
	Over 60	158	26	17 (11 - 23)	
Sex	Female	2,326	347	15 (13 -16)	0.355
	Male	716	117	16 (14 -19)	
Ethnicity	Irish	2,262	304	13 (12 - 15)	<0.001
	Any other white background	267	44	17 (12 - 22)	
	African and any other black background	65	15	23 (14 - 35)	
	Asian background	393	94	24 (20 - 29)	
	Other	55	7	13 (5.3 - 25)	
Country of birth*	Ireland	2,182	291	13 (12 - 15)	<0.001
	United Kingdom	152	25	16 (11 - 23)	
	India	201	46	23 (17 -29)	
	Philippines	166	45	27 (21 - 35)	
	Poland	24	7	29 (13 -51)	
	USA	22	3	14 (2.9 - 35)	
	Other	295	47	16 (12 - 20)	
Education	Primary	27	4	15 (4 - 34)	0.017
	Secondary	420	53	13 (10 -16)	
	Third level	1,300	229	18 (16 -20)	
	Post-graduate	1,295	178	14 (12 -16)	
Role	Admin	454	44	10 (7.1 - 13)	<0.001
	Medical/dental	460	66	14 (11 - 18)	
	Nursing/ midwifery	1,045	215	21 (18 -23)	
	Allied health	616	61	10 (7.7 - 13)	
	General support	255	30	12 (8.1 -16)	
	Health care assistant	157	42	27 (20 - 34)	

	Other	55	6	11 (4.1 - 22)	
Lives with	Alone	256	21	8 (5.2 -12)	0.004
	With others	2,768	441	16 (15 -17)	
	Missing	18	2	11 (1.4 -35)	
Lives with HCWs	Yes	928	193	21 (18 -24)	<0.001
	No	2,060	262	13 (11 - 14)	
	Missing	54	9	17 (7.9 – 29)	

* Calculated using the Chi-Square test

Table 2d. Prevalence of SARS-CoV-2 antibodies by COVID-19 related characteristics, St James's Hospital

Participant characteristics		**Total**	**SARS-CoV-2 IgG detected**		**P-value***
		N	**n**	**% (95% CI)**	
Contact of a COVID-19 case	Yes	1,185	272	23 (21 - 25)	<0.001
	No	1,847	190	10 (8.9 - 12)	
	Missing	10	2	20 (2.5 - 56)	
Setting of close contact	Contact at work	1,039	225	22 (19 -24)	<0.001
	Contact outside of work	146	47	32 (25 - 40)	
Workplace exposure	Daily contact with COVID-19 patients	510	108	21 (18 - 25)	<0.001
	Daily contact with patients without COVID	1,611	269	17 (15 -19)	
	No patients contact	918	87	9.5 (7.7 - 12)	
Previous COVID-19 like symptoms	No symptoms	1,359	72	5.3 (4.2 – 6.6)	<0.001
	Had symptoms	1,683	392	23 (21 - 25)	
Previous COVID-19 PCR test	Yes	1,685	385	23 (21 - 25)	<0.001
	No	1,353	79	5.8 (4.6 - 7.2)	
Previous positive COVID-19 PCR test	Yes	292	277	94.9 (91.7 - 97.1)	<0.001
	No	2,746	187	6.8 (5.8 – 7.8)	

* Calculated using the Chi-Square test

Table 2e. Prevalence of SARS-CoV-2 antibodies by participant characteristics, University Galway Hospital

Participant characteristics		Total	SARS-CoV-2 IgG detected		P-value*
		N	n	% (95% CI)	
Age groups	18-29	622	29	4.7 (3.1 – 6.6)	0.002
	30-39	786	47	6.0 (4.4 – 7.9)	
	40-49	722	25	3.5 (2.2 – 5.1)	
	50-59	469	7	1.5 (0.6 – 3.0)	
	Over 60	146	4	2.7 (0.8 – 6.9)	
Sex	Female	2,152	75	3.5 (2.8 – 4.3)	0.003
	Male	592	37	6.3 (4.4 – 8.5)	
Ethnicity	Irish	2,182	80	3.7 (2.9 – 4.5)	0.031
	Any other white background	284	18	6.3 (3.8 - 9.8)	
	African and any other black background	48	1	2.1 (0.1 - 11)	
	Asian background	184	13	7.1 (3.8 - 12)	
	Other	46	0	-	
Country of birth*	Ireland	2,091	82	3.9 (3.1 – 4.8)	0.229
	United Kingdom	192	7	3.7 (1.5 - 7.4)	
	India	98	8	8.2 (3.6 - 15)	
	Philippines	25	2	8.0 (1.0 - 26)	
	Poland	48	3	6.3 (0.1 - 17)	
	USA	38	0	-	
	Other	253	10	4.0 (1.9 – 7.2)	
Education	Primary	2	0	-	0.690
	Secondary	264	8	3.0 (1.3 – 5.9)	
	Third level	1,245	54	4.3 (3.3 – 5.6)	
	Post-graduate	1,232	50	4.1 (3.0 – 5.3)	
Role	Admin	349	4	1.2 (3.1 – 2.9)	<0.001
	Medical/dental	522	36	6.9 (4.9 – 9.4)	
	Nursing/ midwifery	1,019	48	4.7 (3.5 - 6.2)	
	Allied health	475	12	2.5 (1.3 – 4.4)	
	General support	179	3	1.7 (0.3 – 4.8)	
	Health care assistant	129	8	6.2 (2.7 - 12)	
	Other	72	1	1.4 (0.1 -7.5)	
Lives with	Alone	223	7	3.1 (1.3 – 6.4)	0.658
	With others	2,518	105	4.2 (3.4 – 5.0)	
	Missing	4	0	-	
Lives with HCWs	Yes	839	41	4.9 (3.5 – 6.6)	0.354
	No	1,859	70	3.8 (3.0 – 4.7)	
	Missing	47	1	2.1 (0.1 – 11.3)	

* Calculated using the Chi-Square test or the Fisher exact test

Table 2f. Prevalence of SARS-CoV-2 antibodies by COVID-19 related characteristics, University Galway Hospital

Participant characteristics		Total N	SARS-CoV-2 IgG detected n	SARS-CoV-2 IgG detected % (95% CI)	P-value*
Contact of a COVID-19 case	Yes	519	53	10 (7.7 – 13)	<0.001
	No	2,224	59	2.7 (2.0 – 3.4)	
	Missing	2	0	-	
Setting of close contact	Contact at work	456	44	9.7 (7.0 – 12.7)	0.255
	Contact outside of work	63	9	14 (6.7 – 25.4)	
Workplace exposure	Daily contact with COVID-19 patients	392	28	7.1 (5.0 – 10)	<0.001
	Daily contact with patients without COVID	1,634	75	4.6 (3.7 -5.7)	
	No patients contact	717	9	1.3 (0.1 – 2.4)	
Previous COVID-19 like symptoms	No symptoms	1,517	20	1.3 (0.8 – 2.0)	<0.001
	Had symptoms	1,228	92	7.5 (6.1 – 9.1)	
Previous COVID-19 PCR test	Yes	1,093	89	8.1 (6.6 – 9.9)	<0.001
	No	1,650	23	1.4 (0.9 – 2.1)	
Previous positive COVID-19 PCR test	Yes	75	73	97.3 (90.7 – 99.7)	<0.001
	No	2,668	39	1.5 (1.0 – 2.0)	

* Calculated using the Chi-Square test or the Fisher exact test

Table 3a. Association between risk factors and the presence of SARS-CoV-2 antibodies, Saint James's Hospital

Participant characteristics		Unadjusted relative risk (95% CI)	P-value	Adjusted relative risk (95% CI)	P-value
Age groups	18-29	1.5 (1.2 – 2.0)	0.001	1.3 (1.0 – 1.8)	0.029
	30-39	1.1 (0.8 - 1.5)	0.468	1.0 (0.7 – 1.3)	0.886
	40-49	0.9 (0.7 – 1.3)	0.718	0.9 (0.7 – 1.2)	0.407
	50-59	Ref.			
	Over 60	1.3 (0.8 -1.9)	0.289	1.3 (0.9 – 1.9)	0.214
Sex	Female	Ref.			
	Male	1.1 (0.9 – 1.3)	0.353	1.1 (0.9 – 1.4)	0.318
Ethnicity	Irish	Ref.			
	Any other white background	1.2 (0.9 – 1.6)	0.168	1.2 (0.9 - 1.5)	0.309
	African and other black background	1.7 (1.1 – 2.7)	0.020	1.4 (0.9 – 2.2)	0.137
	Asian background	1.8 (1.4 – 2.2)	<0.001	1.3 (1.0 – 1.6)	0.052
	Other	0.9 (0.5 -1.9)	0.879	0.7 (0.3 – 1.5)	0.395
Country of birth	Ireland	Ref.			Did not enter
	India	1.7 (1.3 – 2.3)	<0.001		
	Philippines	2.0 (1.6 – 2.7)	<0.001		
	United Kingdom	1.2 (0.8 – 1.8)	0.272		
	Poland	2.2 (1.2 – 4.1)	0.015		
	USA	1.0 (0.4 - 2.9)	0.967		
	Other	1.2 (0.9 – 1. 6)	0.218		
Education	Primary	1.1 (0.4 – 2.7)	0.872		Did not enter
	Secondary	0.9 (0.7 – 1.2)	0.558		
	Third level	1.3 (1.1 - 1.5)	0.007		
	Post-graduate	Ref.			
Role	Admin	Ref.			
	Doctor\Dental	1.5 (1.0 - 2.2)	0.032	1.0 (0.7 – 1.5)	0.840
	Nursing	2.1 (1.6 – 2.9)	<0.001	1.6 (1.1 – 2.2)	0.013
	HCA	2.8 (1.9– 4.0)	<0.001	2.0 (1.3 – 3.0)	0.002
	General support	1.2 (0.8 – 1.9)	0.386	1.0 (0.6 – 1.5)	0.870
	Allied HCWs	1.0 (0.7 – 1.5)	0.909	0.9 (0.6 – 1.3)	0.522
	Other	1.1 (0.5 – 2.8)	0.773	1.2 (0.5 – 2.6)	0.734
Lives with	Alone	Ref.			
	With others	1.9 (1.3 – 3.0)	0.002	1.6 (1.0 – 2.4)	0.037
Lives with HCWs	No	Ref.			

	Yes	1.6 (1.4 - 1.9)	<0.001	1.6 (1.0 – 2.4)	0.037
Contact of a COVID-19 case	No	Ref.			Did not enter
	Yes	2.2 (1.9 – 2.6)	<0.001		
Close contact at work **	No	1.5 (1.1 – 1.9)	0.003		Did not enter
	Yes	Ref.			
Workplace exposure to COVID-19 patients	No patients contact	Ref.			
	Daily contact with patients without COVID	1.8 (1.4 – 2.2)	<0.001	1.3 (1.0 – 1.7)	0.0398
	Daily contact with COVID-19 patients	2.2 (1.7 – 2.9)	<0.001	1.4 (1.0 – 1.9)	0.036
Previous COVID-19 like symptoms	No	Ref.			Did not enter
	Yes	4.4 (3.5 – 5.6)	<0.001		

**Calculated for close contacts of COVID-19 cases only (n=1,185)

Table 3b. Association between risk factors and the presence of SARS-CoV-2 antibodies, University Hospital Galway

Participant characteristics		**Unadjusted relative risk (95% CI)**	**P-value**	**Adjusted relative risk (95% CI)**	**P-value**
Age groups	18-29	3.2 (1.4 – 7.1)	0.006	2.7 (1.2 – 6.2)	0.018
	30-39	4.0 (1.8 – 8.8)	<0.001	3.5 (1.6 – 7.6)	0.002
	40-49	2.3 (1.0 – 5.3)	0.047	2.0 (1.0 – 5.0)	0.064
	50-59	Ref.			
	Over 60	1.8 (0.5 -6.2)	0.327	2.1 (0.6 – 6.9)	0.241
Sex	Female	Ref.			
	Male	1.8 (1.2 – 2.6)	0.003	1.9 (1.2 – 3.0)	0.005
Ethnicity	Irish	Ref.			
	Any other white background	1.7 (1.0 – 2.8)	0.031	1.6 (1.0 - 2.6)	0.072
	African and other black background	0.6 (0.1 – 4.0)	0.570	0.4 (0.1 – 2.5)	0.295
	Asian background	1.9 (1.1 – 3.4)	0.023	1.0 (0.6 – 1.9)	0.921
	Other	no observation	-	-	-
Country of birth	Ireland	Ref.			Did not enter
	India	2.1 (1.0 – 4.2)	0.039		

	Philippines	2.0 (0.5 – 7.8)	0.29		
	United Kingdom	0.9 (0.4 – 2.0)	0.850		
	Poland	1.6 (0.5 – 4.9)	0.413		
	USA	no observation	-		
	Other	1.0 (0.5 – 1.9)	0.981		
Education	Primary	no observation	-		Did not enter
	Secondary	0.7 (0.4 – 1.6)	0.436		
	Third level	1.1 (0.7 - 1.6)	0.729		
	Post-graduate	Ref.			
Role	Admin	Ref.			
	Doctor\Dental	6.0 (2.2 - 17)	0.001	2.4 (0.8 – 7.6)	0.126
	Nursing	4.1 (1.5 – 11)	0.006	2.2 (0.7 – 6.7)	0.157
	HCA	5.4 (1.7 – 14)	0.005	2.7 (0.8 – 9.4)	0.122
	General support	1.5 (0.3 - 6.5)	0.616	0.6 (0.1 – 2.7)	0.445
	Allied HCWs	2.2 (0.7 – 6.8)	0.168	1.4 (0.4 – 4.4)	0.571
	Other	1.2 (0.1 – 11)	0.863	0.6 (0.1 – 5.0)	0.607
Lives with	Alone	Ref.			
	With others	1.3 (0.6 – 2.8)	0.460	1.0 (0.5 – 2.2)	0.920
Lives with HCWs	No	Ref.			
	Yes	1.3 (0.9 -1.9)	0.175	0.9 (0.6 – 1.4)	0.736
Contact of a COVID-19 case	No	Ref.			Did not enter
	Yes	3.9 (2.7 – 5.5)	<0.001		
Close contact at work **	No	1.5 (0.8 – 2.9)	0.249		Did not enter
	Yes	Ref.			
Workplace exposure to COVID-19 patients	No patients contact	Ref.			
	Daily contact with patients without COVID	3.7 (1.8 – 7.3)	<0.001	2.0 (0.9 – 4.4)	0.069
	Daily contact with COVID-19 patients	5.7 (2.7 –12)	<0.001	3.1 (1.3 – 6.9)	0.009
Previous COVID-19 like symptoms	No	Ref.			Did not enter
	Yes	5.7 (3.5– 9.2)	<0.001		

**Calculated for close contacts of COVID-19 cases only (n=519)