

# Prevalence of Antibodies to SARS-CoV-2 natural infection and post-vaccination in Irish Hospital Healthcare Workers (PRECISE 2)

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## Summary (main body page 7)

### Background

Hospital healthcare workers (HCW) are at increased risk of contracting SARS-CoV-2 infection. We aimed to determine the seroprevalence of SARS-CoV-2 antibodies in HCW in Ireland, and to compare the seroprevalence in the same HCW at two points in time. Two tertiary referral hospitals in Irish cities with diverging community incidence and seroprevalence were identified; COVID-19 had been diagnosed in 10.2% and 1.8% of staff respectively by the time of the first cross-sectional study (PRECISE 1, October 2020, during the second wave of the pandemic in Ireland). Community seroprevalence after the first wave of the pandemic was 3.1% and 0.6% respectively. Results of PRECISE 1 showed an overall SARS-CoV-2 seroprevalence of 15% in SJH and 4.1% in UHG, with higher adjusted relative risk (aRR) for male sex, age group 18-29, Asian ethnicity, direct patient contact, role of nurse or healthcare assistant, living with others and living with other HCW (1) (2).

This document pertains to the second cross-sectional study (PRECISE 2), which took place six months after PRECISE 1 (in April 2021, during the decline of the third wave of the pandemic in Ireland). By April 2021, occupational health data showed that COVID-19 infection had been diagnosed in 18.5% and 9.2% of staff in SJH and UHG respectively. PRECISE 2 took place four months after the start of vaccination at both sites. The aim of PRECISE 2 was to assess changes in overall seroprevalence with progression of the pandemic, and to further identify HCW risks for seropositivity (demographic, work-related and living arrangements). We also aimed to assess serological response to vaccination in the vaccinated cohort, and to examine changes

in individual serostatus over the six-month period between PRECISE 1 and PRECISE 2 for those staff members who participated both times.

## Methods

All staff of both hospitals (N=9038) were invited to participate in an online questionnaire and blood sampling for SARS-CoV-2 antibody testing in April 2021, in a similar manner to in October 2020 (1). We measured anti-nucleocapsid (N) antibodies and anti-spike (S) antibodies on all samples, using the Roche Elecsys anti-SARS-CoV-2 and Roche Elecsys anti-SARS-CoV-2 S immunoassays, respectively. A participant was presumed to have had COVID-19 infection at some stage if anti-N antibody was detected, or if anti-S antibody was detected without a history of vaccination. Detection of anti-S antibody in vaccinated participants was considered to be as a result of vaccination. All vaccines available to participants were as part of a two-dose regime. A participant was considered fully vaccinated at  $\geq 14$  days after the second dose vaccine. Frequencies and percentages for positive SARS-CoV-2 antibody were calculated and adjusted relative risks (aRR) for participant characteristics were calculated using multivariable regression analysis. Participants common to both serosurveys had their results linked to assess antibody loss or gain.

## Results

### Seroprevalence of past infection

5085 HCW participated in PRECISE 2 (56% response rate). Seroprevalence of antibodies to SARS-CoV-2 (indicative of past infection) was 21% and 13% in SJH and UHG respectively. The adjusted relative risk (aRR) for hospital data combined was higher for working in SJH, age

18-29, male sex, Black ethnicity, lower level of education, role of healthcare assistant (HCA), role of nurse, living with other HCW, and working directly with patients. Risk factors differed by hospital. Of those that were seropositive, 19% had never had symptoms consistent with COVID-19 infection, and 26% had never been diagnosed with COVID-19 infection.

### PRECISE 1 versus PRECISE 2; summary of findings

#### Findings common to both

- Demographic risk factors: younger age group, males, and minority ethnic groups.
- Living arrangement risk factor: living with other HCWs.
- Work-related risks: close patient contact (especially with COVID-19 patients), especially HCAs, followed by nurses.
- The proportion of infections that had been previously undiagnosed remains high (although decreased from 39% to 26%).

#### Main differences in findings

- Expected rise in overall seroprevalence following the third wave of the COVID-19 pandemic nationally.
- Different ethnic group highlighted in each study (October 2020 Asian ethnicity, April 2021 Black ethnicity)
- Lower level of education associated with seropositivity in April 2021.

- Seroprevalence by role; large increase in seroprevalence amongst general support staff

### Serological Response to Vaccination

Ninety-five percent of participants (4854/5085) had started or completed a COVID-19 vaccination course; 81% (4130/5085) of participants had received two doses of vaccine. All recipients of two vaccine doses had detectable anti-S antibodies in response to vaccination. There were 23 breakthrough infections in participants who had received their second dose of vaccine  $\geq 14$  days prior to PCR-confirmed infection, representing 0.6% (23/4111) of all fully vaccinated participants. There were 93 infections in participants who had received only 1 dose of the vaccine, or had received their 2<sup>nd</sup> dose  $< 15$  days before their infection, representing 13% (93/724) of partially vaccinated participants. Ninety-nine percent (713/716) of partially vaccinated participants had detectable anti-S antibodies.

### Change in Antibody Response over time (six-months) from PRECISE 1 to PRECISE 2

In total, 3,313 participants were common to both PRECISE 1 (October 2020) and PRECISE 2 (April 2021). Of those participants who took part in both phases and were antibody positive in October 2020 (n=360), 90% (325/360) remained antibody positive. Among the 3,313, 9.7% (35/360) who were previously seropositive became seronegative, and 7.9% (235/2953) who were previously seronegative became seropositive.

### Conclusion

The increase in seroprevalence from October 2020 to April 2021 reflects the magnitude of the third wave of the pandemic in both locations. Risk was higher in the hospital situated in a higher density area with higher community incidence throughout the COVID-19 pandemic. These findings highlight community incidence as one of the main risks to HCW. Workplace related factors also increased risk; risk was higher for HCW with close patient contact. Hospital outbreaks, hospital infrastructure, and social and demographic factors also may have played a role in the differing seroprevalence at each site, and within each role group. However, in the absence of real time genomic sequencing, the attributable risk attributable of the workplace versus the household/community cannot be further defined.

We identified living with other HCW as an independent risk factor for seropositivity in both studies; to the best of our knowledge there is no other published literature commenting specifically on this risk factor. The other risk factors that we identified are consistent with the published literature, including age, male sex, having direct patient contact, being a HCA or a nurse, and being of Black, Asian ethnicity. Ninety percent of those who were seropositive in October 2020 and participated in April 2021, remained seropositive.

The antibody response to vaccination is reassuring, however we did show confirmed infection in a small minority of fully vaccinated participants; further studies are needed to correlate serological and T cell response with functional immunity. Specific vaccine effectiveness studies are needed to characterise breakthrough infections post vaccination and to estimate protection from infection, particularly with the ongoing emergence of variants of concern. With emerging evidence of reduction in transmission from vaccinated individuals, the authors strongly endorse immediate vaccination of all HCW. Messaging to

HCW regarding the role and limits of vaccination need to be clear and should include the ongoing risk of infection and transmission. Ongoing adherence to all infection prevention and control standards in the healthcare setting and household are paramount in light of the proportion of undiagnosed infections, and the breakthrough infections in fully vaccinated participants. Easy access to testing of HCW with symptoms (including mild symptoms) and in the setting of close contact with a confirmed case of COVID-19 infection should continue, and vaccinated HCW with PCR-confirmed SARS-CoV-2 infection should be actively assessed to advance understanding of the reasons for breakthrough infection. This should include seeking further information on patient biological factors, whole genome sequencing (WGS) of the virus from breakthrough infection HCW cases, and/or index cases identified by follow-up.

## **Main Body**

### **Background**

#### COVID-19 infection in hospital healthcare workers

Healthcare workers, and those they live with, are at increased risk of contracting SARS-CoV-2 viral infection (3) (4) (5). Detectable antibody to SARS-CoV-2 is an excellent indicator of COVID-19 infection (6). A high proportion of the COVID-19 infections notified in Ireland have been in hospital healthcare workers (HCW) and antibody seroprevalence has been shown to be up to six times as high as the background community seroprevalence (7) (8) (1).

Understanding the transmission and potential immunity dynamics of SARS-CoV-2 in hospitals in Ireland is important in mitigating transmission at hospital level and adds

valuable information to the growing evidence base on the transmission patterns of COVID-19 among HCW.

### Antibody response following infection and vaccination

Natural infection has been shown to produce humoral and cellular immunity and whilst this may decline over time, durable memory responses are seen; infection-induced immunity has been shown to protect for up to nine months (9) (10). Although the duration of the detectable antibody response to SARS CoV2 can vary depending on the antigenic target and method of detection (11) (12), there is emerging evidence of a rich and sustained memory response in many individuals. Vaccines have been shown to be protective both against infection and against symptomatic disease (13) (14) (15) (16). Vaccination is also associated with lower viral loads and decreased duration of oropharyngeal PCR positivity which are very likely to correlate with decreased transmissibility (17). Vaccine-induced immunity produces a more robust response the adaptive immune system therefore vaccination is likely to produce a sustained immune response with immunological memory and sustained protection, including against variants of concern (VoC) (18) (19). Immunity after natural infection may not protect against re-infection with variants of concern (20), while vaccine-induced immunity is reduced, but not lost, against variants of concern (21) (22) (23). Robust B and T cell responses to vaccination have been shown for both mRNA vaccines and viral vector vaccines (24). Antibody response has been shown to correlate with protective immunity against infection (25).

The spike (S) and nucleocapsid (N) proteins are two of the main immunogens of the coronavirus proteins (26). Commercial SARS-CoV-2 antibody assays can detect antibodies to these structural proteins. Natural infection can produce either anti-N antibodies, anti-S



antibodies, both anti-N and anti-S antibodies, or neither antibody. Currently available vaccines against COVID-19 infection produce anti-S antibodies only.

### Study sites – 2020 epidemiology

St. James's Hospital (SJH) is a tertiary referral hospital in the south inner city of Dublin, the capital city of Ireland (population 1.2 million) and has almost 4,700 employees and just over 1000 beds. From March-May 2020 (first wave of the pandemic in Ireland, (27)) 9.6% of the staff of SJH tested positive for SARS-CoV-2 infection via polymerase chain reaction (PCR), and by the start of October (the start of the second wave of the pandemic in Ireland, (27)) 10.2% of staff had tested positive by PCR. University Hospital Galway (UHG) is a comparable tertiary referral hospital with almost 4400 employees and over 500 beds, located in Galway, in the West of Ireland (population 80,000); 1.8% of its HCW had a PCR-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.

SJH is one of the largest acute hospitals in Dublin city; UHG is the main acute hospital serving the city of Galway. Both hospitals received patients with COVID-19 infection throughout the first wave of the COVID-19 pandemic in Ireland, and breakdown by ward and specialty is similar.

The community incidence of COVID-19 infection in County Galway was significantly lower than in County Dublin during the first and second waves of the pandemic in Ireland (27). The community seroprevalence was assessed by the Study to Investigate COVID-19 Infection in People Living in Ireland (SCOPI) (28) in June/July 2020 (at the end of the first wave).

Seroprevalence was found to be significantly lower in the West of Ireland (Sligo) at 0.6% compared with the greater Dublin area at 3.1% (28) (29).

The first part of the PRECISE Study (PRECISE 1) was conducted in October 2020, during the second wave of the pandemic in Ireland, and prior to national roll-out of COVID-19 vaccination. This was a cross-sectional seroprevalence study of antibodies to SARS-CoV-2 in all HCW at each of these hospital sites. Results of PRECISE 1 showed an overall SARS-CoV-2 seroprevalence of 15% in SJH and 4.1% in UHG. Almost 40% of infections had been previously undiagnosed, and at least 16% of infections were asymptomatic. Risk for seropositivity was higher for healthcare assistants, nurses, daily exposure to patients (especially patients with confirmed/suspected COVID-19 infection), age 18-29 years, living with other HCW, Asian ethnicity and male sex (1) (2). The HCW seroprevalence was six times higher than community seroprevalence (28).

#### Study sites - 2021 epidemiology

The gap in COVID-19 incidence between Galway and Dublin during the third wave of the COVID-19 pandemic was narrower than during the first two waves; for a 2 week period in late January 2021 the 14-day incidence for Galway approached that of Dublin (30). At the start of this second seroprevalence study in April 2021, the incidence was 181/100,000 in Dublin and 83/100,000 in Galway (31). By the start of April 2021 (third wave of the pandemic in Ireland, (32)) the cumulative incidence of PCR-confirmed infections in HCW in SJH and UHG had risen to 18.5% and 9.2% respectively.

The purpose of this repeat cross-sectional study (PRECISE 2) was to re-assess the prevalence of anti-SARS-CoV-2 antibodies in HCW in these two hospitals following the third, and larger,

wave of the pandemic in Ireland, and to relate risk of COVID-19 infection in HCW to demographic, living arrangements and work-related factors in order to inform ongoing risk reduction activities. We aimed to assess:

1. Changes in overall seroprevalence over a six-month period in these distinct geographical areas.
2. Serological response to COVID-19 vaccination in the vaccinated sub-group.
3. Changes in individual serostatus over time (six-months) for those who participated in PRECISE 1 and PRECISE 2 (note provisional results for this section, with further detailed analysis to follow).

## **Methods**

### Study Design and participants

This was a cross-sectional study of the seroprevalence of circulating antibodies to SARS-CoV-2, carried out from the 19<sup>th</sup>-28<sup>th</sup> April 2021, with longitudinal linking of participants who also took part in the first serosurvey (PRECISE 1) carried out from the 14<sup>th</sup>-23<sup>rd</sup> October 2020. All staff members of both hospitals (N=9038) were invited to participate in an online self-administered consent process and online questionnaire, followed by blood sampling for SARS-CoV-2 antibody testing in April 2021, in the same manner as PRECISE 1 (1). Electronic consent and patient reported outcomes were captured using Castor; an eClinical platform that enables decentralised clinical trials (33). Following completion of the online consent and questionnaire, participants were automatically directed to an online platform to book a blood test on site at their place of work (34). Technical support and walk-in phlebotomy

clinics were provided for participants who had difficulty with the online consent process. Information collected in the questionnaire included demographic information, contact details, place and type of work, level of contact with patients, previous COVID-19 symptoms and testing, history of close contact with a confirmed case of COVID-19, living arrangements and history of COVID-19 vaccination, including dates and type of vaccine. Blood samples were processed anonymously via a unique participant identifier (MRN), which was generated by the online blood booking system. This MRN was later used by the study team to link results to individual participants to deliver results. Results were sent by text message to all participants on an opt-out basis. Results were discussed in person with any participant who requested this.

All vaccinated study participants received their SARS-CoV-2 vaccine as part of a two-dose regimen, of either the Comirnaty (Pfizer/BioNTech) vaccine, the Vaxzevria (formerly AstraZeneca) vaccine or the Moderna vaccine. The National Immunisation Advisory Committee (NIAC) currently states that recipients of the Vaxzevria (AstraZeneca) may not have optimal protection until 15 days after the second dose of vaccine, recipients of the Moderna vaccine may not have optimal protection until 14 days after the second dose of vaccine, and recipients of the Comirnaty (Pfizer/BioNTech) vaccine may not have optimal protection until 7 days after the second dose of vaccine (35). It's generally accepted that SARS-CoV-2 vaccine recipients may not have optimal protection until  $\geq 15$  days after the second vaccine dose (16). For the purposes of this study, a participant was considered fully vaccinated at  $\geq 14$  days after receipt of the second dose of vaccination, in line with Irish guidelines (35). A participant was considered partially vaccinated  $\geq 14$  days after receipt of the first dose of vaccination (35,36). A participant was considered to have started a

vaccination course once one dose of vaccine had been received at any stage prior to the study.

### Laboratory Methods

All samples were tested using the Roche Elecsys anti-SARS-CoV-2 and the Roche Elecsys anti-SARS-CoV-2 S immunoassays detecting total antibodies (including IgG) to the nucleocapsid and spike proteins of the SARS-CoV-2 virus, respectively (37). Thresholds for positive results were as per manufacturers' guidelines (37) (38). Participants with detectable anti-N antibodies were presumed to have had previous natural infection. Participants with detectable anti-S antibodies, and no reported history of COVID-19 vaccination were also presumed to have had natural infection. Participants with detectable anti-S antibodies and a history of COVID-19 vaccination were presumed to have these anti-S antibodies in response to vaccination.

### Statistical analysis

Frequencies and percentages were calculated for sociodemographic, epidemiological, and clinical characteristics. Participants were deemed seropositive (i.e. assumed to have had past infection with SARS-CoV-2) if they had detectable anti- N antibodies, or if they had detectable anti-S antibodies but had not been previously vaccinated. Characteristics of those who were seropositive were compared to those who were not seropositive, using the chi-square test. Univariable logistic regression was used to calculate relative risks along with their 95% confidence intervals to assess the association between SARS-CoV-2 seropositivity 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). No explicit finite population correction or reweighting was carried out. All analysis was conducted in Stata 15.1 (StataCorp LCC. 2019. College Station, TX 77845: USA).

### 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). Ethical approval was revised in February 2021 to allow the study to take into account the rollout of COVID-19 vaccination in Ireland – this involved changes to the study questionnaire, and the addition of anti-spike antibody testing on all samples. This work was supported financially by the Irish Health Service Executive COVID-19 budget.

### **Results**

1. SARS-CoV-2 seroprevalence (past infection)

#### Participation rates and demographics

All staff working in SJH and UHG (9,038 people) were invited to participate in the study. In total 5,108 (57%) blood samples were collected and of those 99% (n=5,085) had a matching questionnaire (questionnaires were deemed to be completed if at least 80% of the questions were answered). In SJH, 63% (2945/4692) of staff participated in both questionnaire and blood sample. In UHG, 49% (2140/4346) of staff participated in both questionnaire and blood sample.

Age and sex of participants were similar in both hospitals (Table 1a). On combined hospital data, 78% of participants were female. Median age was 40 years (IQR 30-49); 5.5% of

participants were aged 60 or older. By ethnicity; 75% of participants were white Irish (71% in SJH and 80% in UHG), 12% were Asian (16% in SJH and 6.0% in UHG), and 2.3% were of African or any other black background (2.3% in SJH and 2.2% in UHG). Ninety-one percent of participants lived with other people and 31% lived with other HCW. The highest proportion (37%) of participants were nursing staff, 21% were allied healthcare staff, 14% medical/dental staff (12% in SJH and 17% in UHG), 13% administration staff, 7.2% general support staff (8.3% SJH and 5.7% UHG), 5.7% health care assistants (HCA) and 2.1% other healthcare staff.

Participation by staff grouping was similar in both hospitals; allied health staff had the highest response rate in both hospitals (82% and 67% participation in SJH and UHG respectively) and HCAs had the lowest response rate in both hospitals (42% and 35% participation in SJH and UHG respectively). Participants broadly reflected the HCW breakdown of the staff in both hospitals, with allied health staff slightly over-represented (+5.1%), and HCAs, administration staff, medical/dental staff and nursing/midwifery staff slightly under-represented (for details on participation by HCW role see Table A-D, Annex).

**Table 1a** Participant characteristics by hospital and total number of participants, PRECISE 2, April 2021

| Participant characteristics |        | St James's Hospital |     | University Hospital Galway |     | P-value* | Total (N=5,085) |     |
|-----------------------------|--------|---------------------|-----|----------------------------|-----|----------|-----------------|-----|
|                             |        | (N=2,945)           |     | (N=2,140)                  |     |          | N               | %   |
|                             |        | n                   | %   | n                          | %   |          |                 |     |
| <b>Age groups</b>           | 18-29  | 653                 | 22  | 455                        | 21  | 0.431    | 1,108           | 22  |
|                             | 30-39  | 765                 | 26  | 565                        | 26  |          | 1,330           | 26  |
|                             | 40-49  | 811                 | 28  | 603                        | 28  |          | 1,414           | 28  |
|                             | 50-59  | 565                 | 19  | 386                        | 18  |          | 951             | 19  |
|                             | ≥60    | 151                 | 5.1 | 131                        | 6.1 |          | 282             | 5.5 |
| <b>Sex</b>                  | Female | 2,278               | 77  | 1,681                      | 79  | 0.309    | 3,959           | 78  |
|                             | Male   | 667                 | 23  | 459                        | 21  |          | 1,126           | 22  |
|                             | Irish  | 2,091               | 71  | 1,707                      | 80  |          | 3,798           | 75  |

|                         |                            |       |     |       |      |        |       |      |
|-------------------------|----------------------------|-------|-----|-------|------|--------|-------|------|
| <b>Ethnicity</b>        | Any other white background | 257   | 8.7 | 219   | 10   | <0.001 | 476   | 9.4  |
|                         | Asian background           | 470   | 16  | 129   | 6.0  |        | 599   | 12   |
|                         | African/other black        | 69    | 2.3 | 48    | 2.2  |        | 117   | 2.3  |
|                         | Other                      | 58    | 2.0 | 37    | 1.7  |        | 95    | 1.9  |
| <b>Country of birth</b> | Ireland                    | 2,025 | 69  | 1605  | 75   | <0.001 | 3,630 | 71   |
|                         | United Kingdom             | 134   | 4.6 | 161   | 7.5  |        | 295   | 5.8  |
|                         | India                      | 225   | 7.6 | 68    | 3.2  |        | 293   | 5.8  |
|                         | Philippines                | 198   | 6.7 | 16    | 0.7  |        | 214   | 4.2  |
|                         | Poland                     | 26    | 0.9 | 59    | 2.8  |        | 85    | 1.7  |
|                         | USA                        | 21    | 0.7 | 34    | 1.6  |        | 55    | 1.1  |
|                         | Other                      | 316   | 11  | 197   | 9.2  |        | 513   | 10   |
| <b>Education</b>        | Primary                    | 20    | 0.7 | 2     | 0.1  | <0.001 | 22    | 0.4  |
|                         | Secondary                  | 409   | 14  | 200   | 9.3  |        | 609   | 12   |
|                         | Third level                | 1,280 | 43  | 964   | 45   |        | 2,244 | 44   |
|                         | Post-graduate              | 1,236 | 42  | 974   | 46   |        | 2,210 | 43   |
| <b>Role</b>             | Admin                      | 403   | 14  | 273   | 13   | <0.001 | 676   | 13   |
|                         | Medical/dental             | 357   | 12  | 356   | 17   |        | 713   | 14   |
|                         | Nursing/ midwifery         | 1097  | 37  | 794   | 37   |        | 1,891 | 37   |
|                         | Allied health              | 612   | 21  | 432   | 20   |        | 1,044 | 21   |
|                         | General support            | 243   | 8.3 | 122   | 5.7  |        | 365   | 7.2  |
|                         | Health care assistant      | 179   | 6.1 | 112   | 5.2  |        | 291   | 5.7  |
|                         | Other                      | 54    | 1.8 | 51    | 2.4  |        | 105   | 2.1  |
| <b>Lives with</b>       | Alone                      | 270   | 9.2 | 194   | 9.1  | 0.603  | 464   | 9.1  |
|                         | With others                | 2,667 | 90. | 1,943 | 90.8 |        | 4,610 | 90.7 |
|                         | Missing                    | 8     | 0.3 | 3     | 0.1  |        | 11    | 0.2  |
| <b>Lives with HCW</b>   | Yes                        | 928   | 32  | 643   | 30   | 0.284  | 1,571 | 31   |
|                         | No                         | 1,964 | 67  | 1,448 | 68   |        | 3,412 | 67   |
|                         | Missing                    | 53    | 1.8 | 49    | 2.3  |        | 102   | 2.0  |

\*Calculated using the chi-square test

### Previous exposure, symptoms and testing

COVID-19 related characteristics of participants differed by hospital (Table 1b). Overall, 22% of participating HCWs reported that their main type of daily work involved contact with patients with suspected or confirmed COVID-19 (25% of participants in SJH and 19% of participants in UHG), a further 49% reported that their main type of daily work involved contact with patients without suspected COVID-19 infection (46% in SJH and 53% in UHG), and 28% had little or no patient contact (29% in SJH and 28% in UHG). Symptoms consistent with COVID-19 had occurred at some stage in 47% of SJH staff and 37% of UHG staff.

Among the 43% of participants (in both hospitals) who had symptoms at some stage; 30% of



these were mild symptoms (equal to a cold or less), 12% were significant symptoms (similar to influenza, bed-ridden), and 0.9% were severe symptoms (requiring hospitalisation). A higher proportion of participants in SJH experienced significant symptoms (14%) when compared to UHG (9.4%).

In terms of self-reported previous laboratory-confirmed COVID-19 infection, 18% of participants in SJH and 14% of participants in UHG reported that they had previously tested positive by PCR. Among those who were previously PCR positive, 21% did not have symptoms at the time of PCR testing (18% in SJH and 26% in UHG).

**Table 1b** COVID-19 related characteristics by hospital and total number of participants, PRECISE 2, April 2021

| Participant characteristics                           |  | St James's Hospital |     | University Hospital Galway |     | P-value* | Total (N=5,085) |     |
|---|--|---------------------|-----|----------------------------|-----|----------|-----------------|-----|
|   |  | (N=2,945)           |     | (N=2,140)                  |     |          | N               | %   |
|   |  | n                   | %   | n                          | %   |          |                 |     |
| <b>Daily contact with COVID-19 patients</b>           | Contact with COVID-19 patients         | 726                 | 25  | 410                        | 19  | <0.001   | 1136            | 22  |
|   | Contact with patients without COVID-19 | 1,362               | 46  | 1,138                      | 53  |          | 2,500           | 49  |
|   | No patient contact                     | 857                 | 29  | 592                        | 28  |          | 1,449           | 28  |
| <b>Previous COVID-19 symptoms</b>                     | No symptoms                            | 1571                | 53  | 1342                       | 63  | <0.001   | 2913            | 57  |
|   | Had symptoms                           | 1374                | 47  | 797                        | 37  |          | 2171            | 43  |
|   | Missing                                | 0                   | 0.0 | 1                          | 0.0 |          | 1               | 0.0 |
| <b>Severity of symptoms</b>                           | No symptoms                            | 1571                | 53  | 1342                       | 63  | <0.001   | 2913            | 57  |
|   | Mild symptoms                          | 932                 | 32  | 570                        | 27  |          | 1502            | 30  |
|   | Significant symptoms                   | 420                 | 14  | 201                        | 9.4 |          | 621             | 12  |
|   | Severe (hospitalised)                  | 21                  | 0.7 | 26                         | 1.2 |          | 47              | 0.9 |
|   | Type of symptoms                       | 1                   | 0.0 | 0                          | 0.0 |          | 1               | 0.0 |
| <b>Previous positive COVID-19 PCR test</b>            | No                                     | 2427                | 82  | 1846                       | 86  | <0.001   | 4273            | 84  |
|   | Yes                                    | 518                 | 18  | 294                        | 14  |          | 812             | 16  |
| <b>Symptoms at time of previous positive PCR test</b> | No                                     | 95                  | 18  | 77                         | 26  | <0.001   | 172             | 21  |
|   | Yes                                    | 423                 | 82  | 217                        | 74  |          | 640             | 79  |
| <b>Severity of symptoms at time of PCR test</b>       | No symptoms                            | 95                  | 18  | 77                         | 26  | <0.001   | 172             | 21  |
|   | Mild symptoms                          | 162                 | 31  | 94                         | 32  |          | 256             | 32  |
|   | Significant symptoms                   | 248                 | 48  | 103                        | 35  |          | 351             | 43  |
|   | Severe (hospitalised)                  | 12                  | 2.3 | 20                         | 6.8 |          | 32              | 3.9 |
|   | Missing                                | 1                   | 0.2 | 0                          | 0.0 |          | 1               | 0.1 |

\*Calculated using the chi-square test

### SARS-CoV-2 seroprevalence by site

In SJH, seroprevalence among participants was 21%. Seroprevalence was 27% in those who reported having daily contact with COVID-19 patients, 22% in those who reported having daily contact with patients without suspected COVID-19 infection, and 16% in those who had little or no patient contact. In UHG, seroprevalence among participants was 13%. Seroprevalence was 17% in those who reported having daily contact with COVID-19 patients, 15% in those who reported having daily contact with patients without suspected COVID-19 infection, and 6.1% in those who had little or no patient contact.

### Seroprevalence by HCW role

By professional subgroup in SJH, seroprevalence was highest among HCAs (39%), followed by nursing/midwifery staff (26%), general support staff (25%), administrative staff (16%), medical/dental staff (15%), allied health professionals (15%), and other healthcare staff (7.4%) (other healthcare staff had small numbers and included those working in education and research, videographers, undefined technicians and others who did not further define their role). Details of seroprevalence (and 95% Confidence Intervals (CI)) by sociodemographic characteristics and by COVID-19 characteristics are shown in table 2a and 2b respectively.

By professional subgroup in UHG, seroprevalence was highest among HCAs (21%), followed by medical/dental staff (17%), general support staff (17%), nursing/midwifery staff (14%), other healthcare staff (12%), administrative staff (7.7%), and allied health professionals

(6.7%). Details of seroprevalence and 95% CIs by sociodemographic characteristics and by COVID-19 characteristics are shown in table 2c and 2d respectively.

The combined data for both hospitals showed that HCAs were significantly more likely than other professional groups to be seropositive, with 32% of those participating in the study being seropositive. Seroprevalence in general support staff was second highest at 22%, followed by nursing/midwifery (21%). Prevalence of SARS-CoV-2 seropositivity for both hospitals combined, by participant characteristics and by COVID-19 characteristics are shown in Table 2e and 2f, Annex.

The term 'general support staff' includes a range of hospital staff roles; by general support role, seroprevalence was highest among catering staff (28%) and domestic/cleaning staff (22%); a detailed breakdown by hospital is shown in Table 2g, Annex.

**Table 2a** Prevalence of SARS-CoV-2 seropositivity by participant characteristics, St James’s Hospital, PRECISE 2, April 2021

| Participant characteristics |                                       | Total | SARS-CoV-2 seropositive |                |          |
|-----------------------------|---------------------------------------|-------|-------------------------|----------------|----------|
|                             |                                       | N     | n                       | % (95% CI)     | p-value* |
| <b>Overall</b>              |                                       | 2945  | 623                     | 21 (20 - 23)   | -        |
| <b>Age groups (years)</b>   | 18-29                                 | 653   | 159                     | 24 (21 - 28)   | 0.184    |
|                             | 30-39                                 | 765   | 154                     | 20 (17 - 23)   |          |
|                             | 40-49                                 | 811   | 157                     | 19 (17 - 22)   |          |
|                             | 50-59                                 | 565   | 119                     | 21 (18 - 25)   |          |
|                             | Over 60                               | 151   | 34                      | 23 (16 - 30)   |          |
| <b>Sex</b>                  | Female                                | 2,278 | 471                     | 21 (19 - 22)   | 0.240    |
|                             | Male                                  | 667   | 152                     | 23 (20 - 26)   |          |
| <b>Ethnicity</b>            | Irish                                 | 2,091 | 401                     | 19 (18 - 21)   | <0.001   |
|                             | Any other white background            | 257   | 56                      | 22 (17 - 27)   |          |
|                             | Asian background                      | 470   | 122                     | 26 (22 - 30)   |          |
|                             | African or any other black background | 69    | 29                      | 42 (30 - 55)   |          |
|                             | Other                                 | 58    | 15                      | 26 (15 - 39)   |          |
| <b>Country of birth</b>     | Ireland                               | 2,025 | 386                     | 19 (17 - 21)   | 0.001    |
|                             | United Kingdom                        | 134   | 25                      | 19 (12 - 26)   |          |
|                             | India                                 | 225   | 60                      | 27 (21 - 33)   |          |
|                             | Philippines                           | 198   | 53                      | 27 (21 - 34)   |          |
|                             | Poland                                | 26    | 8                       | 31 (14 - 52)   |          |
|                             | USA                                   | 21    | 4                       | 19 (5.4 - 42)  |          |
|                             | Romania                               | 40    | 12                      | 30 (17 - 47)   |          |
|                             | Nigeria                               | 25    | 18                      | 72 (51 - 88)   |          |
|                             | Other                                 | 251   | 57                      | 23 (18 - 28)   |          |
| <b>Education</b>            | Primary                               | 20    | 7                       | 35 (15 - 59)   | <0.001   |
|                             | Secondary                             | 409   | 105                     | 26 (22 - 30)   |          |
|                             | Third level                           | 1,280 | 301                     | 24 (21 - 26)   |          |
|                             | Post-graduate                         | 1,236 | 210                     | 17 (15 - 19)   |          |
| <b>Role</b>                 | Admin                                 | 403   | 64                      | 16 (12 - 20)   | <0.001   |
|                             | Medical/dental                        | 357   | 55                      | 15 (12 - 20)   |          |
|                             | Nursing/ midwifery                    | 1097  | 281                     | 26 (23 - 28)   |          |
|                             | Allied health                         | 612   | 89                      | 15 (12 - 18)   |          |
|                             | General support                       | 243   | 60                      | 25 (19 - 31)   |          |
|                             | Health care assistant                 | 179   | 70                      | 39 (32 - 47)   |          |
|                             | Other                                 | 54    | 4                       | 7.4 (2.1 - 18) |          |
| <b>Lives with</b>           | Alone                                 | 270   | 42                      | 16 (11 - 20)   | 0.019    |
|                             | With others                           | 2,667 | 578                     | 22 (20 - 23)   |          |
|                             | Missing                               | 8     | 3                       | 38 (8.5 - 76)  |          |
| <b>Lives with HCW</b>       | Yes                                   | 928   | 234                     | 25 (22 - 28)   | <.001    |
|                             | No                                    | 1,964 | 376                     | 19 (17 - 21)   |          |
|                             | Missing                               | 53    | 13                      | 25 (14 - 38)   |          |

\*Calculated using the Chi-square test

**Table 2b** Prevalence of SARS-CoV-2 seropositivity by COVID-19 related characteristics, St James's Hospital, PRECISE 2, April 2021

| COVID-19 related characteristics                 |  | Total | SARS-CoV-2 seropositive |                  |          |
|--|--|-------|-------------------------|------------------|----------|
|  |  | N     | n                       | % (95% CI)       | p-value* |
| <b>Daily contact with COVID-19 patients</b>      | Contact with COVID-19 patients         | 726   | 196                     | 27 (24 - 30)     | <0.001   |
|  | Contact with patients without COVID-19 | 1,362 | 293                     | 22 (19 - 24)     |          |
|  | No patient contact                     | 857   | 134                     | 16 (13 - 18)     |          |
| <b>Previous COVID-19 symptoms</b>                | No symptoms                            | 1571  | 121                     | 7.7 (6.4 - 9.1)  | <0.001   |
|  | Had symptoms                           | 1374  | 502                     | 37 (34 - 39)     |          |
|  | Missing                                | 0     | 0                       | -                |          |
| <b>Severity of symptoms</b>                      | No symptoms                            | 1571  | 121                     | 7.7 (6.4 - 9.1)  | <0.001   |
|  | Mild symptoms                          | 932   | 228                     | 24 (22 - 27)     |          |
|  | Significant symptoms                   | 420   | 262                     | 62 (58 - 67)     |          |
|  | Severe (hospitalised)                  | 21    | 12                      | 57 (34 - 78)     |          |
|  | Missing                                | 1     | 0                       | -                |          |
| <b>Previous positive COVID-19 PCR test</b>       | No                                     | 2427  | 190                     | 7.8 (6.8 - 9.0)  | <0.001   |
|  | Yes                                    | 518   | 433                     | 84 (80 - 87)     |          |
| <b>Symptoms at time of previous positive PCR</b> | No                                     | 95    | 51                      | 54 (43 - 64)     | <0.001   |
|  | Yes                                    | 423   | 382                     | 90.3 (87 - 93.0) |          |
| <b>Severity of symptoms at time of PCR test</b>  | No symptoms                            | 95    | 51                      | 54 (43 - 64)     | <0.001   |
|  | Mild symptoms                          | 162   | 143                     | 88 (82 - 92.8)   |          |
|  | Significant symptoms                   | 248   | 227                     | 91.5 (87 - 94.7) |          |
|  | Severe (hospitalised)                  | 12    | 12                      | 100 (74 - 100)   |          |
|  | Missing                                | 1     | 0                       | -                |          |

\*Calculated using the Chi-square test

**Table 2c** Prevalence of SARS-CoV-2 seropositivity by participant characteristics, University Hospital Galway, PRECISE 2, April 2021

| Participant characteristics |                                       | Total | SARS-CoV-2 seropositive |                 |          |
|-----------------------------|---------------------------------------|-------|-------------------------|-----------------|----------|
|                             |                                       | N     | n                       | % (95% CI)      | p-value* |
| <b>Overall</b>              |                                       | 2140  | 275                     | 13 (11 - 14)    | -        |
| <b>Age groups (years)</b>   | 18-29                                 | 455   | 90                      | 20 (16 - 24)    | <0.001   |
|                             | 30-39                                 | 565   | 84                      | 15 (12 - 18)    |          |
|                             | 40-49                                 | 603   | 51                      | 8.5 (6.4 - 11)  |          |
|                             | 50-59                                 | 386   | 39                      | 10 (7.3 - 14)   |          |
|                             | Over 60                               | 131   | 11                      | 8.4 (4.3 - 15)  |          |
| <b>Sex</b>                  | Female                                | 1,681 | 198                     | 12 (10 - 13)    | 0.005    |
|                             | Male                                  | 459   | 77                      | 17 (13 - 21)    |          |
| <b>Ethnicity</b>            | Irish                                 | 1,707 | 194                     | 11 (10 - 13)    | 0.002    |
|                             | Any other white background            | 219   | 38                      | 17 (13 - 23)    |          |
|                             | Asian background                      | 129   | 26                      | 20 (14 - 28)    |          |
|                             | African or any other black background | 48    | 10                      | 21 (10 - 35)    |          |
|                             | Other                                 | 37    | 7                       | 19 (8.0 - 35)   |          |
| <b>Country of birth</b>     | Ireland                               | 1605  | 181                     | 11 (10 - 13)    | <0.001   |
|                             | United Kingdom                        | 161   | 19                      | 12 (7.3 - 18)   |          |
|                             | India                                 | 68    | 16                      | 24 (14 - 35)    |          |
|                             | Poland                                | 59    | 12                      | 20 (11 - 33)    |          |
|                             | USA                                   | 34    | 7                       | 21 (8.7 - 38)   |          |
|                             | Philippines                           | 16    | 1                       | 6.3 (0.2 - 30)  |          |
|                             | Nigeria                               | 10    | 1                       | 10 (0.3 - 45)   |          |
|                             | Romania                               | 5     | 3                       | 60 (14 - 95)    |          |
| Other                       | 182                                   | 39    | 19 (13 - 36)            |                 |          |
| <b>Education</b>            | Primary                               | 2     | 0                       | -               | 0.485    |
|                             | Secondary                             | 200   | 28                      | 14 (10 - 20)    |          |
|                             | Third level                           | 964   | 133                     | 14 (12 - 16)    |          |
|                             | Post-graduate                         | 974   | 114                     | 12 (10 - 14)    |          |
| <b>Role</b>                 | Admin                                 | 273   | 21                      | 7.7 (4.8 - 12)  | <0.001   |
|                             | Medical/dental                        | 356   | 61                      | 17 (13 - 21)    |          |
|                             | Nursing/ midwifery                    | 794   | 114                     | 14 (12 - 17)    |          |
|                             | Allied health                         | 432   | 29                      | 6.7 (4.5 - 9.5) |          |
|                             | General support                       | 122   | 21                      | 17 (11 - 25)    |          |
|                             | Health care assistant                 | 112   | 23                      | 21 (13 - 29)    |          |
|                             | Other                                 | 51    | 6                       | 12 (4.4 - 24)   |          |
| <b>Lives with</b>           | Alone                                 | 194   | 19                      | 10 (6.0 - 15)   | 0.180    |
|                             | With others                           | 1,943 | 256                     | 13 (12 - 15)    |          |
|                             | Missing                               | 3     | 0                       | -               |          |
| <b>Lives with HCW</b>       | Yes                                   | 643   | 106                     | 16 (14 - 20)    | 0.001    |
|                             | No                                    | 1448  | 164                     | 11 (10 - 13)    |          |
|                             | Missing                               | 49    | 5                       | 10 (3.4 - 22)   |          |

\*Calculated using the Chi-square test

**Table 2d** Prevalence of SARS-CoV-2 seropositivity by COVID-19 characteristics, University Hospital Galway, PRECISE 2, April 2021

| COVID-19 related characteristics                      |  | Total |     | SARS-CoV-2 seropositive |          |
|---|--|-------|-----|-------------------------|----------|
|   |  | N     | n   | % (95% CI)              | p-value* |
| <b>Daily contact with COVID-19 patients</b>           | Contact with COVID-19 patients         | 410   | 69  | 17 (13 - 21)            | <0.001   |
|   | Contact with patients without COVID-19 | 1,138 | 170 | 15 (13 - 17)            |          |
|   | No patient contact                     | 592   | 36  | 6.1 (4.3 - 8.3)         |          |
| <b>Previous COVID-19 symptoms</b>                     | No symptoms                            | 1342  | 48  | 3.6 (2.6 - 4.7)         | <0.001   |
|   | Had symptoms                           | 797   | 227 | 28 (25 - 32)            |          |
|   | Missing                                | 1     | 0   | -                       |          |
| <b>Severity of symptoms</b>                           | No symptoms                            | 1342  | 48  | 3.6 (2.6 - 4.7)         | <0.001   |
|   | Mild symptoms                          | 570   | 107 | 19 (16 - 22)            |          |
|   | Significant symptoms                   | 201   | 102 | 51 (48 - 58)            |          |
|   | Severe (hospitalised)                  | 26    | 18  | 69 (44 - 86)            |          |
|   | Missing                                | 0     | 0   | -                       |          |
| <b>Previous positive COVID-19 PCR</b>                 | No                                     | 1846  | 45  | 2.4 (1.8 - 3.2)         | <0.001   |
|   | Yes                                    | 294   | 230 | 78 (73 - 83)            |          |
| <b>Symptoms at time of previous positive PCR test</b> | No                                     | 77    | 36  | 47 (35 - 58)            | <0.001   |
|   | Yes                                    | 217   | 194 | 89 (85 - 93.2)          |          |
| <b>Severity of symptoms at time of PCR test</b>       | No symptoms                            | 77    | 36  | 47 (35 - 58)            | <0.001   |
|   | Mild symptoms                          | 94    | 83  | 88 (80 - 94.0)          |          |
|   | Significant symptoms                   | 103   | 93  | 90.3 (83 - 95.2)        |          |
|   | Severe (hospitalised)                  | 20    | 18  | 90.0 (68 - 99.0)        |          |
|   | Missing                                | 0     | 0   | -                       |          |

\*Calculated using the Chi-square test

### Asymptomatic SARS-CoV-2 infection

The combined data for both hospitals shows that 19% (191/623) of seropositive participants had asymptomatic SARS-CoV-2 infection at some stage (i.e. they were seropositive in this study but reported never having symptoms of COVID-19). Asymptomatic infection by ethnic group was highest among those of African or other black background (36%), followed by white Irish background (20%), other white background (19%), Asian (12%), and other background (9.1%), but confidence intervals overlap. The breakdown was similar by hospital

location; breakdown of asymptomatic infection by hospital and HCW role is shown in Table 2h, Annex.

Among those that had asymptomatic infection (antibody positive and never had symptoms), 33% (55/169) had been previously diagnosed positive by PCR, and 67% (114/169) had not.

Among these 114 with previously undiagnosed asymptomatic infection, 73% (83/114) were white Irish, 12% (14/114) were of other white background, 8.8% (10/114) Asian, 4.4% (5/114) African or other black background, and 1.8% (2/114) other background.

#### Seropositivity by previous diagnosis and symptoms

Sixteen percent (812/5085) of participants reported having had a PCR-confirmed infection with COVID-19 at some stage. Of these, 82% (663/812) were seropositive and 18%

(149/812) were seronegative, Table 2f. This meant that 3.6% (149/4187) of all participants who were seronegative had previously had a PCR-confirmed infection with COVID-19.

Breakdown by hospital is shown in Tables 2b and 2d. The majority of those reporting a previous confirmed COVID-19 infection were symptomatic at the time of their positive PCR (640/812; 79%), Table 2f. Seroprevalence among those that were symptomatic (576/640; 90%) was significantly higher than seroprevalence among those who were asymptomatic at the time of their confirmed COVID-19 infection (87/172; 51%), ( $p < .001$ ).

In total, 29% (1480/5085) of participants reported that they had experienced symptoms at some stage but had never had a positive PCR test. Of these, 121/1480 (8.2%) were seropositive. Thirty-two of these 121 participants who had never been tested by PCR reported significant COVID-19 like symptoms at some stage.

#### Undiagnosed SARS-CoV-2 infection



In total, 898 participants (623 in SJH and 275 in UHG) were seropositive. Of these, 235/898 (26%) had never been diagnosed with COVID-19 infection, representing 4.6% (235/5085) of the total study population. The majority of these undiagnosed infections were SJH employees (190/235; 81%). In SJH, 30% (190/623) of those who were seropositive had never previously been diagnosed, and in UHG 16% (45/275) of those who were seropositive had never previously been diagnosed.

Just over half of those with undiagnosed infection (121/235; 51%) had experienced COVID-19 like symptoms at some stage; of those 74% (89/121) had experienced mild symptoms and 26% (32/121) had experienced significant symptoms. This proportion of undiagnosed participants who experienced only mild symptoms (89/121, 74%) was much higher than the proportion of diagnosed participants who experienced only mild symptoms (226/576; 34%) (Table E, Annex).

By ethnicity, the highest proportion (160/235; 68%) of HCWs with undiagnosed infection was white Irish, 14% (33/235) were Asian, 12% (28/235) were of other white background, 3% (6/235) were of African or other black background, and 3% (8/235) were of other ethnic background. Most participants with undiagnosed infection reported daily patient contact in their role (192/235; 82%); 36% (84/192) had daily contact with COVID-19 patients and 46% (108/192) had daily contact with patients without suspected COVID-19 infection. By professional role, 42% (98/235) of undiagnosed HCWs were nurses, 12% (28/235) were HCAs and 9% (20/235) were in medical/dental roles (of which 18 were doctors). The proportion of undiagnosed participants that were medical/dental professionals was higher

in UHG (18%) than in SJH (6.3%). Detailed analysis of undiagnosed infection by HCW role and by hospital location is shown in Table 2i, Annex.

#### Risk factors for seropositivity

Characteristics of those participants who were seropositive compared with those who were seronegative for both hospitals combined are shown in Tables 2e and 2f (Annex). Those of male sex, and those in the 18-29-year age group had a higher seroprevalence; 20% of all participating males had detectable antibody versus 17% of females ( $p=.008$ ), and 22% of all participants aged 18-29 were seropositive ( $p<.001$ ). By ethnicity 33% of participants of African or other black background were seropositive, versus 16% of white Irish participants ( $p<.001$ ). By country of birth, seroprevalence was highest in participants born in Nigeria (54%), Romania (33%), and India (26%), but it should be noted that there were a low number ( $<100$ ) of participants born in either Nigeria or Romania. Seroprevalence decreased with increasing education level (from 32% for those with primary level education to 15% of those with post-graduate level education,  $p<.001$ ). Seroprevalence was 32% for HCAs, 22% for general support staff, 21% for nurses, 16% for medical/dental staff, 13% for admin staff, 11% for allied health staff and 10% for other staff ( $p<.001$ ). Eighteen percent of those living with others were seropositive, compared to 13% of those living alone ( $p=.008$ ), and 22% of those living with other HCWs were seropositive compared with 16% of those not living with HCWs ( $p<.001$ ). Twenty-three percent of those who had daily contact with COVID-19 patients were seropositive, compared to 19% of those who had daily contact with patients without COVID-19, and 12% of those who had little or no patient contact ( $p<.001$ ).

By hospital, seroprevalence was higher in SJH (21%; 95% CI 20-23) when compared to UHG (13%; 95% CI 11-14) ( $p<.001$ ). The characteristics of participants who were seropositive in each hospital are shown in Tables 2a-2d. The main differences in seropositivity between the

two hospitals were for age, sex, education and living arrangements. For UHG, younger age groups had higher seropositivity (20% seropositivity among 18-29 year-olds versus 10% seropositivity among 50-59 year-olds,  $p < .001$ ), but this was not observed for SJH (Tables 2a and 2c). For UHG there was also higher seroprevalence amongst those of male sex (17% seropositivity among males versus 12% seropositivity among females,  $p = .005$ ), but this difference was less pronounced for SJH. For SJH, seroprevalence decreased with increasing education level ( $p < .001$ ), but this was not observed in UHG. The association between being seropositive and living arrangements was stronger in SJH compared to UHG; in SJH, 22% of participants that were living with other people were seropositive compared to 16% of participants that were living alone ( $p = .019$ ). The association between seropositivity and living with other HCWs was strong in both hospitals. The differences in breakdown by professional subgroup are described above.

On multivariable analysis by hospital, in SJH the aRR of seropositivity was statistically significant for the following characteristics: being a healthcare assistant (aRR 1.9, 95% CI 1.4-2.6,  $p < .001$ ), being a nurse (aRR 1.5, 95% CI 1.1-2.0,  $p = 0.008$ ), being of African or other black background (aRR 1.8, 95% CI 1.3-2.4,  $p < .001$ ), secondary level education (aRR 1.5, 95% CI 1.2-1.9,  $p = 0.002$ ), and living with other HCW (aRR 1.2, 95% CI 1.0-1.4,  $p = 0.011$ ), see Table 3a.

In UHG, the aRR of seropositivity was statistically significant for the following characteristics: daily contact with COVID-19 patients (aRR 2.1, 95% CI 1.4-3.3,  $p = 0.001$ ), daily contact with patients without suspected or confirmed COVID-19 (aRR 1.9, 95% CI 1.3-2.9,  $p = 0.001$ ), being aged 18-29 years (aRR 1.7, 95% CI 1.2-2.4,  $p = 0.004$ ).

On multivariable analysis of the combined hospital data, the adjusted relative risk (aRR) of seropositivity was statistically significant for the following characteristics: working in SJH (aRR 1.5, 95% CI 1.3-1.8,  $p < .001$ ), being a healthcare assistant (aRR 1.8, 95% CI 1.3-2.3,  $p < .001$ ), being of African or other black background (aRR 1.7, 95% CI 1.3-2.2,  $p < .001$ ), secondary level education (aRR 1.4, 95% CI 1.1-1.8,  $p = 0.002$ ), being a nurse (aRR 1.4, 95% CI 1.0-1.8,  $p = 0.022$ ), daily contact with COVID-19 patients (aRR 1.4, 95% CI 1.1-1.7,  $p = 0.002$ ), daily contact with patients without suspected or confirmed COVID-19 (aRR 1.3, 95% CI 1.1-1.5,  $p = 0.013$ ), being 18-29 years of age (aRR 1.3, 95% CI 1.1-1.6,  $p = 0.002$ ), being male (aRR 1.2, 95% CI 1.0-1.4,  $p = 0.016$ ), and living with other HCW (aRR 1.2, 95% CI 1.0-1.4,  $p = 0.007$ ), Table 3c.

**Table 3a** Association between risk factors and SARS-CoV-2 seropositivity, St James's Hospital, PRECISE 2, April 2021

| Participant characteristics |                                   | Unadjusted relative risk<br>(95% CI) | P-value          | Adjusted relative risk<br>(95% CI) | P-value          |
|-----------------------------|-----------------------------------|--------------------------------------|------------------|------------------------------------|------------------|
| <b>Age groups (years)</b>   | 18-29                             | 1.2 (0.9 - 1.4)                      | 0.174            | 1.2 (1.0 - 1.5)                    | 0.107            |
|                             | 30-39                             | 1.0 (0.8 - 1.2)                      | 0.677            | 1.0 (0.8 - 1.3)                    | 0.909            |
|                             | 40-49                             | 0.9 (0.7 - 1.1)                      | 0.437            | 1.0 (0.8 - 1.2)                    | 0.887            |
|                             | 50-59                             | Ref.                                 |                  | Ref.                               |                  |
|                             | Over 60                           | 1.1 (0.8 - 1.5)                      | 0.697            | 1.0 (0.8 - 1.5)                    | 0.655            |
| <b>Sex</b>                  | Female                            | Ref.                                 |                  | Ref.                               |                  |
|                             | Male                              | 1.1 (0.9 - 1.3)                      | 0.237            | 1.2 (1.0 - 1.4)                    | 0.104            |
| <b>Ethnicity</b>            | Irish                             | Ref.                                 |                  | Ref.                               |                  |
|                             | Any other white background        | 1.1 (0.9 - 1.5)                      | 0.312            | 1.1 (0.8 - 1.4)                    | 0.516            |
|                             | Asian background                  | 1.4 (1.1 - 1.6)                      | 0.001            | 1.1 (0.9 - 1.3)                    | 0.571            |
|                             | African or other black background | <b>2.2 (1.6 - 2.9)</b>               | <b>&lt;0.001</b> | <b>1.8 (1.3 - 2.4)</b>             | <b>&lt;0.001</b> |
|                             | Other                             | 1.3 (0.9 - 2.1)                      | 0.187            | 1.3 (0.8 - 2.0)                    | 0.249            |
| <b>Country of birth</b>     | Ireland                           | Ref.                                 |                  |                                    | not entered      |
|                             | India                             | 1.4 (1.1 - 1.8)                      | 0.005            |                                    |                  |
|                             | Philippines                       | 1.4 (1.1 - 1.8)                      | 0.007            |                                    |                  |
|                             | United Kingdom                    | 1.0 (0.7 - 1.4)                      | 0.908            |                                    |                  |
|                             | Poland                            | 1.6 (0.9 - 2.9)                      | 0.108            |                                    |                  |
|                             | USA                               | 1.0 (0.4 - 2.4)                      | 0.999            |                                    |                  |
|                             | Romania                           | 1.6 (1.0 - 2.5)                      | 0.065            |                                    |                  |
|                             | Nigeria                           | 3.8 (2.9 - 4.9)                      | <0.001           |                                    |                  |
|                             | Other                             | 1.2 (0.9 - 1.5)                      | 0.162            |                                    |                  |
|                             | <b>Education</b>                  | Primary                              | 2.1 (1.1 - 3.8)  | 0.020                              | 1.6 (0.9 - 2.9)  |
| Secondary                   |                                   | <b>1.5 (1.2 - 1.9)</b>               | <b>&lt;0.001</b> | <b>1.5 (1.2 - 1.9)</b>             | <b>0.002</b>     |
| Third level                 |                                   | 1.4 (1.2 - 1.6)                      | <0.001           | 1.2 (1.0 - 1.4)                    | 0.103            |
| Post-graduate               |                                   | Ref.                                 |                  | Ref.                               |                  |
|                             |                                   |                                      |                  |                                    |                  |
| <b>Role</b>                 | Admin                             | Ref.                                 |                  | Ref.                               |                  |
|                             | Doctor\Dental                     | 1.0 (0.7 - 1.4)                      | 0.857            | 0.9 (0.6 - 1.3)                    | 0.673            |
|                             | Nursing                           | <b>1.6 (1.3 - 2.1)</b>               | <b>&lt;0.001</b> | <b>1.5 (1.1 - 2.0)</b>             | <b>0.008</b>     |
|                             | HCA                               | <b>2.5 (1.8 - 3.3)</b>               | <b>&lt;0.001</b> | <b>1.9 (1.4 - 2.6)</b>             | <b>&lt;0.001</b> |
|                             | General support                   | 1.6 (1.1 - 2.1)                      | 0.006            | 1.3 (0.9 - 1.8)                    | 0.152            |

|  |  |                        |                  |                        |              |
|--|--|------------------------|------------------|------------------------|--------------|
|  | Allied HCW                                   | 0.9 (0.7 - 1.2)        | 0.559            | 0.9 (0.7 - 1.3)        | 0.754        |
|  | Other  | 0.5 (0.2 - 1.2)        | 0.123            | 0.4 (0.2 - 1.1)        | 0.093        |
| <b>Lives with</b>                              | Alone  | Ref.                   |                  |                        | not entered  |
|  | With others                                  | 1.4 (1.0 - 1.9)        | 0.024            |                        |              |
| <b>Lives with HCW</b>                          | No   | Ref.                   |                  | Ref.                   |              |
|  | Yes  | <b>1.3 (1.1 - 1.5)</b> | <b>&lt;0.001</b> | <b>1.2 (1.0 - 1.4)</b> | <b>0.011</b> |
| <b>Workplace exposure to COVID-19 patients</b> | No patient contact                           | Ref.                   |                  | Ref.                   |              |
|  | Daily contact with patients without COVID-19 | 1.4 (1.1 - 1.7)        | 0.001            | 1.2 (0.9 - 1.4)        | 0.270        |
|  | Daily contact with COVID-19 patients         | 1.7 (1.4 - 2.1)        | <0.001           | 1.2 (1.0 - 1.5)        | 0.090        |
| <b>Previous COVID-19 like symptoms</b>         | No   | Ref.                   |                  |                        | not entered  |
|  | Yes  | 4.7 (3.9 - 5.7)        | <0.001           |                        |              |
| <b>Severity of symptoms</b>                    | No symptoms                                  | Ref.                   |                  |                        | not entered  |
|  | Mild symptoms                                | 3.2 (2.6 - 3.9)        | <0.001           |                        |              |
|  | Significant symptoms                         | 8.1 (6.7 - 9.8)        | <0.001           |                        |              |
|  | Severe symptoms (hospitalisation)            | 7.4 (4.9 - 11.2)       | <0.001           |                        |              |

**Table 3b** Association between risk factors and SARS-CoV-2 seropositivity, University Hospital Galway, PRECISE 2, April 2021

| Participant characteristics |                                   | Unadjusted relative risk<br>(95% CI) | P-value          | Adjusted relative<br>risk (95% CI) | P-value      |
|-----------------------------|-----------------------------------|--------------------------------------|------------------|------------------------------------|--------------|
| <b>Age groups (years)</b>   | 18-29                             | <b>2.0 (1.4 - 2.8)</b>               | <b>&lt;0.001</b> | <b>1.7 (1.2 - 2.4)</b>             | <b>0.004</b> |
|                             | 30-39                             | 1.5 (1.0 - 2.1)                      | 0.034            | 1.3 (0.9 - 1.9)                    | 0.120        |
|                             | 40-49                             | 0.8 (0.6 - 1.2)                      | 0.380            | 0.8 (0.5 - 1.2)                    | 0.304        |
|                             | 50-59                             | Ref.                                 |                  | Ref.                               |              |
|                             | Over 60                           | 0.8 (0.4 - 1.6)                      | 0.570            | 0.8 (0.4 - 1.5)                    | 0.501        |
| <b>Sex</b>                  | Female                            | Ref.                                 |                  | Ref.                               |              |
|                             | Male                              | 1.4 (1.1 - 1.8)                      | 0.004            | 1.3 (1.0 - 1.7)                    | 0.097        |
| <b>Ethnicity</b>            | Irish                             | Ref.                                 |                  | Ref.                               |              |
|                             | Any other white background        | 1.5 (1.1 - 2.1)                      | 0.009            | 1.3 (1.0 - 1.7)                    | 0.078        |
|                             | Asian background                  | 1.8 (1.2 - 2.6)                      | 0.002            | 1.2 (0.8 - 1.8)                    | 0.333        |
|                             | African or other black background | 1.8 (1.0 - 3.2)                      | 0.036            | 1.3 (0.7 - 2.4)                    | 0.388        |
|                             | Other                             | 1.7 (0.8 - 3.3)                      | 0.142            | 1.4 (0.7 - 2.8)                    | 0.328        |
| <b>Country of birth</b>     | Ireland                           | Ref.                                 |                  |                                    | not entered  |
|                             | India                             | 2.1 (1.3 - 3.3)                      | 0.001            |                                    |              |
|                             | Philippines                       | 0.6 (0.1 - 3.7)                      | 0.543            |                                    |              |
|                             | United Kingdom                    | 1.0 (0.7 - 1.6)                      | 0.841            |                                    |              |
|                             | Poland                            | 1.8 (1.1 - 3.0)                      | 0.027            |                                    |              |
|                             | USA                               | 1.8 (0.9 - 3.6)                      | 0.080            |                                    |              |
|                             | Romania                           | 5.3 (2.6 - 11)                       | <0.001           |                                    |              |
|                             | Nigeria                           | 0.9 (0.1 - 5.7)                      | 0.899            |                                    |              |
|                             | Other                             | 1.7 (1.2 - 2.4)                      | 0.001            |                                    |              |
|                             |                                   |                                      |                  |                                    |              |
| <b>Education</b>            | Primary                           | -                                    |                  |                                    | not entered  |
|                             | Secondary                         | 1.2 (0.8 - 1.8)                      | 0.361            |                                    |              |
|                             | Third level                       | 1.2 (0.9 - 1.5)                      | 0.168            |                                    |              |
|                             | Post-graduate                     |                                      |                  |                                    |              |
| <b>Role</b>                 | Admin                             | Ref.                                 |                  | Ref.                               |              |
|                             | Doctor\Dental                     | 2.2 (1.4 - 3.6)                      | 0.001            | 0.9 (0.5 - 1.5)                    | 0.660        |
|                             | Nursing                           | 1.9 (1.2 - 2.9)                      | 0.006            | 1.0 (0.6 - 1.6)                    | 0.901        |

|  |  |                        |                  |                        |              |
|--|--|------------------------|------------------|------------------------|--------------|
|  | HCA  | 2.7 (1.5 - 4.6)        | <0.001           | 1.5 (0.8 - 2.7)        | 0.180        |
|  | General support                              | 2.2 (1.3 - 3.9)        | 0.005            | 1.1 (0.6 - 2.1)        | 0.704        |
|  | Allied HCW                                   | <b>0.9 (0.5 - 1.5)</b> | <b>0.622</b>     | <b>0.6 (0.3 - 1.0)</b> | <b>0.053</b> |
|  | Other  | 1.5 (0.6 - 3.6)        | 0.331            | 0.8 (0.3 - 1.8)        | 0.533        |
| <b>Lives with</b>                              | Alone  | Ref.                   |                  |                        | not entered  |
|  | With others                                  | 1.3 (0.9 - 2.1)        | 0.188            |                        |              |
| <b>Lives with HCW</b>                          | No   | Ref.                   |                  | Ref.                   |              |
|  | Yes  | 1.5 (1.2 - 1.8)        | 0.001            | 1.1 (0.9 - 1.4)        | 0.317        |
| <b>Workplace exposure to COVID-19 patients</b> | No patient contact                           | Ref.                   |                  | Ref.                   |              |
|  | Daily contact with patients without COVID-19 | <b>2.5 (1.7 - 3.5)</b> | <b>&lt;0.001</b> | <b>1.9 (1.3 - 2.9)</b> | <b>0.001</b> |
|  | Daily contact with COVID-19 patients         | <b>2.8 (1.9 - 4.1)</b> | <b>&lt;0.001</b> | <b>2.1 (1.4 - 3.3)</b> | <b>0.001</b> |
| <b>Previous COVID-19 like symptoms</b>         | No   | Ref.                   |                  |                        | not entered  |
|  | Yes  | 8 (5.9 - 10.7)         | <0.001           |                        |              |
| <b>Severity of symptoms</b>                    | No symptoms                                  | Ref.                   |                  |                        | not entered  |
|  | Mild symptoms                                | 5.2 (3.8 - 7.3)        | <0.001           |                        |              |
|  | Significant symptoms                         | 14.2 (10.4 - 19.3)     | <0.001           |                        |              |
|  | Severe symptoms (hospitalisation)            | 19.4 (13.3 - 28.2)     | <0.001           |                        |              |

**Table 3c** Association between risk factors and SARS-CoV-2 seropositivity, both hospitals, PRECISE 2, April 2021

| Participant characteristics |                            | Unadjusted relative risk (95% CI) | P-value          | Adjusted relative risk (95% CI) | P-value          |
|-----------------------------|----------------------------|-----------------------------------|------------------|---------------------------------|------------------|
| <b>Hospital</b>             | Galway University Hospital | Ref.                              |                  |                                 |                  |
|                             | St James's Hospital        | <b>1.6 (1.4 - 1.9)</b>            | <b>&lt;0.001</b> | <b>1.5 (1.3 - 1.8)</b>          | <b>&lt;0.001</b> |
| <b>Age groups (years)</b>   | 18-29                      | <b>1.4 (1.1 - 1.6)</b>            | <b>0.001</b>     | <b>1.3 (1.1 - 1.6)</b>          | <b>0.002</b>     |
|                             | 30-39                      | 1.1 (0.9 - 1.3)                   | 0.427            | 1.1 (0.9 - 1.3)                 | 0.299            |
|                             | 40-49                      | 0.9 (0.7 - 1.1)                   | 0.209            | 1.0 (0.7 - 1.1)                 | 0.569            |
|                             | 50-59                      | Ref.                              |                  | Ref.                            |                  |
|                             | Over 60                    | 1.0 (0.7 - 1.3)                   | 0.794            | 1.0 (0.7 - 1.3)                 | 0.948            |
| <b>Sex</b>                  | Female                     | Ref.                              |                  | Ref.                            |                  |
|                             | Male                       | <b>1.2 (1.1 - 1.4)</b>            | <b>0.007</b>     | <b>1.2 (1.0 - 1.4)</b>          | <b>0.016</b>     |



|  |  |                        |                  |                        |                  |
|--|--|------------------------|------------------|------------------------|------------------|
| <b>Ethnicity</b>                               | Irish  | Ref.                   |                  | Ref.                   |                  |
|  | Any other white background                   | 1.3 (1.0 - 1.5)        | 0.020            | 1.2 (1.0 - 1.4)        | 0.120            |
|  | Asian background                             | 1.6 (1.3 - 1.8)        | <0.001           | 1.1 (0.9 - 1.3)        | 0.206            |
|  | African or other black background            | <b>2.1 (1.6 - 2.8)</b> | <b>&lt;0.001</b> | <b>1.7 (1.3 - 2.2)</b> | <b>&lt;0.001</b> |
|  | Other  | 1.5 (1.0 - 2.1)        | <0.001           | 1.3 (0.9 - 1.9)        | 0.145            |
| <b>Country of birth</b>                        | Ireland                                      | Ref.                   |                  |                        | not entered      |
|  | India  | 1.7 (1.3 - 2.0)        | <0.001           |                        |                  |
|  | Philippines                                  | 1.6 (1.3 - 2.1)        | <0.001           |                        |                  |
|  | United Kingdom                               | 1.0 (0.7 - 1.3)        | 0.749            |                        |                  |
|  | Poland                                       | 1.5 (1.0 - 2.2)        | 0.040            |                        |                  |
|  | USA  | 1.3 (0.8 - 2.2)        | 0.364            |                        |                  |
|  | Romania                                      | 2.1 (1.4 - 3.2)        | <0.001           |                        |                  |
|  | Nigeria                                      | 3.5 (2.5 - 4.8)        | <0.001           |                        |                  |
|  | Other  | 1.4 (1.1 - 1.7)        | 0.002            |                        |                  |
|  | <b>Education</b>                             | Primary                | 2.2 (1.2 - 4.0)  | 0.014                  | 1.6 (0.9 - 2.9)  |
| Secondary                                      |  | <b>1.5 (1.2 - 1.8)</b> | <b>&lt;0.001</b> | <b>1.4 (1.1 - 1.8)</b> | <b>0.002</b>     |
| Third level                                    |  | 1.3 (1.2 - 1.5)        | <0.001           | 1.1 (1.0 - 1.3)        | 0.133            |
| Post-graduate                                  |  | Ref.                   |                  | Ref.                   |                  |
| <b>Role</b>                                    |  | Admin                  | Ref.             |                        | Ref.             |
|  | Doctor\Dental                                | 1.3 (1.0 - 1.7)        | 0.051            | 1.0 (0.7 - 1.4)        | 0.973            |
|  | Nursing                                      | 1.7 (1.3 - 2.1)        | <0.001           | 1.4 (1.0 - 1.8)        | 0.022            |
|  | HCA  | <b>2.5 (2.0 - 3.3)</b> | <b>&lt;0.001</b> | <b>1.8 (1.3 - 2.3)</b> | <b>&lt;0.001</b> |
|  | General support                              | 1.8 (1.3 - 2.3)        | <0.001           | 1.2 (0.9 - 1.7)        | 0.144            |
|  | Allied HCW                                   | 0.9 (0.7 - 1.2)        | 0.424            | 0.8 (0.6 - 1.1)        | 0.119            |
|  | Other  | 0.8 (0.4 - 1.4)        | 0.381            | 0.7 (0.3 - 1.2)        | 0.134            |
|  | <b>Lives with</b>                            | Alone                  | Ref.             |                        |                  |
| With others                                    |  | 1.4 (1.1 - 1.8)        | 0.010            |                        |                  |
| <b>Lives with HCW</b>                          | No   | Ref.                   |                  | Ref.                   |                  |
|  | Yes  | <b>1.3 (1.2 - 1.5)</b> | <b>&lt;0.001</b> | <b>1.2 (1.0 - 1.4)</b> | <b>0.007</b>     |
| <b>Workplace exposure to COVID-19 patients</b> | No patient contact                           | Ref.                   |                  | Ref.                   |                  |
|  | Daily contact with patients without COVID-19 | <b>1.6 (1.3 - 1.9)</b> | <b>&lt;0.001</b> | <b>1.3 (1.1 - 1.5)</b> | <b>0.013</b>     |
|  | Daily contact with COVID-19 patients         | <b>2.0 (1.7 - 2.4)</b> | <b>&lt;0.001</b> | <b>1.4 (1.1 - 1.7)</b> | <b>0.002</b>     |
| <b>Previous COVID-19 like symptoms</b>         | No   | Ref.                   |                  |                        | not entered      |
|  | Yes  | 5.8 (4.9 - 6.8)        | <0.001           |                        |                  |
|  | No symptoms                                  | Ref.                   |                  |                        | not entered      |

|                             |                                   |                   |        |
|-----------------------------|-----------------------------------|-------------------|--------|
| <b>Severity of symptoms</b> | Mild symptoms                     | 3.8 (3.2 - 4.6)   | <0.001 |
|                             | Significant symptoms              | 10.1 (8.6 - 11.9) | <0.001 |
|                             | Severe symptoms (hospitalisation) | 11.0 (8.5 - 14.3) | <0.001 |



## 2. Antibody response to vaccination

In total, 95% (4854/5085) of participants had received at least one vaccine dose at the time of this study; 14% (724/5085) had received one dose only, 81% (4130/5085) had received two doses, and 4.5% (231/5085) had not received any vaccine doses. In SJH 78% (2290/2945) were fully vaccinated and 19% (546/2945) had received 1<sup>st</sup> dose of vaccination only, for a total of 96% (2836/2945) participants in SJH having started or completed vaccination. In UHG 86% (1840/2140) were fully vaccinated and 8.3% (178/2140) had received 1<sup>st</sup> dose vaccination only, for a total of 94% (2018/2140) of participants in UHG having received at least one dose of vaccine. The majority of partially vaccinated HCW (680/724) had received Vaxzevria vaccine; roll out of this vaccine was in February 2021 and therefore these participants were not yet due the second dose due to the longer dosing interval of 12 weeks. Vaccination uptake by ethnicity was similar, with 142/3661 (3.9%, 95% CI 3.3-4.6)) of White Irish participants being unvaccinated, compared to 30/571 (5.2%, 95% CI 3.7-7.4) of Asian participants and 7/110 (6.4%, 95% CI 3.1-13) of Black participants. The vaccines received are shown in Table 4.

Table 4. COVID-19 vaccination status and vaccine brand received by participants, both hospitals, April 2021, PRECISE 2

|                               | <b>Started or completed vaccination<sup>^</sup></b> | <b>Fully vaccinated*</b>    |
|-------------------------------|---|-----------------------------|
|                               | <b>n/N (%)</b>                                      | <b>n/N (%)</b>              |
| <b>Hospital data combined</b> | <b>4854/5085 (95.5%)</b>                            | <b>4130/ 5085 (81%)</b>     |
|                               | Pfizer 4156/5085 (82%)                              | Pfizer 4116/5085 (81%)      |
|                               | Vaxzevria 686/5085 (9.5%)                           | Vaxzevria 6/5085 (0.1%)     |
|                               | Moderna 8/5085 (0.2)                                | Moderna 4/5085 (0.08%)      |
|                               | I don't know 6/5085 (0.1)                           | I don't know 2/5085 (0.04%) |
| <b>SJH</b>                    | <b>2836/2945 (96.3%)</b>                            | <b>2290/ 2945 (78%)</b>     |
|                               | Pfizer 2305/ 2945 (78%)                             | Pfizer 2286/ 2945 (78%)     |
|                               | Vaxzevria 526/2945 (18%)                            | Vaxzevria 3/2945 (0.1%)     |
|                               | Moderna 4/2945 (0.1%)                               | Moderna 1/2945 (0.03%)      |
| <b>UHG</b>                    | <b>2018/2140 (94.3%)</b>                            | <b>1840/ 2140 (86%)</b>     |
|                               | Pfizer 1849/2140 (86%)                              | Pfizer 1830/2140 (86%)      |
|                               | Vaxzevria 161/2140 (7.5%)                           | Vaxzevria 3/2140 (0.1%)     |
|                               | Moderna 4/2140 (0.2%)                               | Moderna 3/2140 (0.1%)       |
|                               | I don't know 2/2140 (0.09%)                         | I don't know 2/2140 (0.09%) |

<sup>^</sup>defined as anyone who had received a first dose of vaccine at any stage prior to the study

\*defined as  $\geq 14$  days after receipt of second dose of vaccine

All fully vaccinated participants (4130/4130, 100%) had detectable anti-S antibodies. Of those that had received one dose of vaccine only, 713/724 (98%) had detectable anti-S antibodies. Of the 724 that had received only one dose of vaccine, 716 of them had received their vaccine >14 days prior to blood sampling for our study, and 713/716 (99.6%) had detectable anti-S antibodies.

#### SARS-CoV-2 infection post vaccination

In total, 116 participants reported that they had PCR-confirmed SARS-CoV-2 infection since vaccination; of those 82/116 (71%) had received one vaccine dose only and 34/116 (29%) had received their second dose; 23/116 (20%) of these were fully vaccinated i.e. had received their second dose  $\geq$  15 days before their positive PCR, representing 0.6% (23/4130) of all participants that received two doses and 0.6% (23/4111) of fully vaccinated participants. There were 93 infections in partially vaccinated participants (received only 1 dose of the vaccine or had received their 2<sup>nd</sup> dose <15 days before their infection) representing 93/724 (13%; 95% CI 11 - 16) of partially vaccinated participants having had a PCR-confirmed infection post vaccination compared to 23/4111 (0.6%; 95% CI 0.4 - 0.8) of fully vaccinated participants (p-value= <.001 (chi-square)). All fully and partially vaccinated participants with breakthrough infection had anti-spike antibodies detected; 21/23 of those fully vaccinated had anti-spike detected at >250u/ml (the other two had antibody levels 133u/ml and 242u/ml respectively) and 88/93 of those partially vaccinated had anti-spike detected at >250u/ml (range of 81-202u/ml for the other 5/93).

Of the 23 breakthrough infections in fully vaccinated participants, all had received the Pfizer vaccine. (It is noted that this was the most commonly received vaccine as it was the first

vaccine to be rolled out, and also that the vaccine schedule for the Pfizer vaccine meant that the other vaccines would have less time for breakthrough cases in fully vaccinated recipients to be observed i.e. the majority of those that received Vaxzevria vaccine had not yet received their second dose by the time of the study). The median interval between first and second vaccine dose was 21 days (as recommended before 18<sup>th</sup> January 2021). For those 23 participants, the median number of days between second vaccine dose and PCR positive test was 30 days (IQR 25-50 days). Five (22%) had symptoms at the time of the positive PCR test and 18 (78%) did not have symptoms. While all 23 participants had detectable anti-S antibodies as expected post vaccination, notably, only 6/23 (26%, 95%CI: 11-49) had detectable anti-N antibodies in response to their infection, compared to 663/812 (82%, 95%CI: 79-84, p-value= <.001 (Chi-squared) of all participants in the study with previous PCR-confirmed infection having detectable anti-N antibodies. For the 17 that were anti-N negative after their confirmed infection, the median number of days between PCR positivity and blood sample was 52 days (range 9-67). Characteristics of participants with breakthrough infection are shown in Table F annex. The majority (78%) were working in SJH, 65% were female and by age group the highest proportion (35%) was aged 40-49 years. By ethnicity, just over half (52%) were white Irish and 35% were Asian. Thirty-nine percent had daily contact with COVID-19 patients, and 57% lived with other HCWs.

#### PRECISE 1 and PRECISE 2 comparison

##### Comparison of participation rates and participant demographics

All staff working in SJH and UHG (9,038 people) were invited to participate in both PRECISE 1 (October 2020) and PRECISE 2 (April 2021). Overall, participation was lower in PRECISE 2

(5,085 participants) than in PRECISE 1 (5,787 participants) (1). In SJH, 63% (2945/4692) of staff participated in PRECISE 2; a slight decrease on 65% participation in PRECISE 1, and in UHG, 49% (2140/4346) of staff participated in PRECISE 2, a considerable decrease on 63% participation in PRECISE 1. The decrease in participation rate in UHG was similar across professional subgroups. The distribution of participants in PRECISE 1 and 2 was similar by age group, sex, and education level. By ethnicity, a slightly higher proportion of participants in PRECISE 2 were Asian (12%) when compared to PRECISE 1 (10%). By professional subgroup a slightly higher proportion of participants were allied healthcare workers (19% in PRECISE 1 versus 21% in PRECISE 2;  $p=0.035$ ), a slightly higher proportion were HCAs (5.7% in PRECISE 2 versus 4.9% in PRECISE 1,  $p=0.790$ ), and a lower proportion were medical/dental professionals (14% in PRECISE 2 versus 17% in PRECISE 1;  $p<0.001$ ). A significantly lower proportion of participants in PRECISE 2 had ever experienced symptoms consistent with COVID-19 (47% of participants in SJH, and 37% in UHG) when compared to participants in PRECISE 1 (55% of participants in SJH, and 45% in UHG), ( $p<.001$ ) (1). In terms of self-reported previous laboratory-confirmed COVID-19 infection, a significantly higher proportion of participants in PRECISE 2 reported having previously tested positive by PCR (18% of participants in SJH, and 14% in UHG), compared to PRECISE 1 (9.6% of participants in SJH, and 2.7% in UHG) ( $p<.001$ ). (39).

#### Comparison of crude seroprevalence

A comparison of crude seroprevalence in PRECISE 1 (October 2020) and in PRECISE 2 (April 2021) by participant characteristics and by hospital is shown in Table 5. In SJH, the seroprevalence significantly increased from 15% in PRECISE 1 to 21% in PRECISE 2 ( $p<.001$ ), and in UHG the seroprevalence significantly increased from 4.1% in PRECISE 1 to 13% in



PRECISE 2 ( $p < .001$ ). For both hospitals combined, seroprevalence increased from 10% in PRECISE 1 to 18% in PRECISE 2. For SJH by ethnic group, the increase in seroprevalence was most pronounced for HCWs of African or other black background (from 23% in PRECISE 1 to 42% in PRECISE 2;  $p = 0.020$ ). Increase in seroprevalence in SJH was also significant for those of white Irish ethnicity (from 13% to 19%;  $p < .001$ ) but the increase was not significant for HCWs of Asian ethnicity. By education level in SJH, increase in seroprevalence was highest for HCWs with primary education (from 15% in PRECISE 1 to 35% in PRECISE 2) but this increase was not significant due to low numbers of participants in this group. The increase was also high for those of secondary level education and it was significant (from 13% to 26%;  $p < .001$ ). By professional subgroup in SJH, increase in seroprevalence was highest for general support staff (from 12% in PRECISE 1 to 25% in PRECISE 2;  $p < .001$ ) and for HCAs (from 27% in PRECISE 1 to 39% in PRECISE 2;  $p = 0.017$ ). For UHG by ethnic group, the increase in seroprevalence was also most pronounced for HCWs of African or other black background (from 2.1% in PRECISE 1 to 21% in PRECISE 2;  $p = 0.004$ ). Increase in seroprevalence among HCWs of Asian ethnicity was significant (from 7.1% to 20%;  $p < .001$ ) as was the increase among those of White Irish ethnicity (from 3.7% to 11%;  $p < .001$ ). By professional subgroup in UHG, increase in seroprevalence was also highest for general support staff (from 1.7% in PRECISE 1 to 17% in PRECISE 2;  $p < .001$ ) and for HCAs (from 6.2% in PRECISE 1 to 21% in PRECISE 2;  $p = 0.001$ ). By age group in UHG, the seroprevalence increased from 4.7% in PRECISE 1 to 20% in PRECISE 2 for younger HCWs aged 18-29 years ( $p < .001$ ), (for SJH a small increase was observed for this age group but it was not significant).

For both hospitals combined by ethnic group, the increase in seroprevalence was most pronounced for HCWs of African or other black background (from 14% in PRECISE 1 to 33% in PRECISE 2;  $p=0.001$ ). By education level, increase in seroprevalence was highest for HCWs with primary education (from 14% in PRECISE 1 to 32% in PRECISE 2) but was not significant due to low numbers in this subgroup ( $p=0.121$ ). For those of secondary education the increase was also high (from 8.9% to 22%) and it was significant ( $p<0.001$ ). By professional subgroup, increase in seroprevalence was highest for general support staff (from 7.6% in PRECISE 1 to 22% in PRECISE 2;  $p<.001$ ) and for HCAs (from 18% in PRECISE 1 to 32% in PRECISE 2;  $p<.001$ ).

#### Change in Antibody Response over time (six-months) from PRECISE 1 to PRECISE 2

In total, 3,313 participants were common to both PRECISE 1 and 2. For the purposes of this part of the study, to facilitate direct comparison of individuals who participated in both studies, antibody positivity was defined as a detectable antibody on the Roche Elecsys anti-N total antibody assay, which was used in both studies. This excluded 16 participants who participated both times and had detectable anti-N antibodies on the Abbott Architect IgG assay which was also used in PRECISE 1 but not used in PRECISE 2. (These 16 participants did not have detectable anti-N antibodies on the Roche assay in PRECISE 1).

In total, 17.9% (595/3313) of matched qualifying participants were ever seropositive in PRECISE 1 or 2; 10.9% (360/3313) were positive in PRECISE 1, 16.9% (560/3313) were positive in PRECISE 2, and 9.8% (325/3313) were seropositive in both PRECISE 1 and 2. Of those participants who took part in both phases and were antibody positive in PRECISE 1 ( $n=360$ ), 90% (325/360) remained antibody positive. Among the 3,313, 9.7% (35/360) who were previously seropositive became seronegative, and 7.9% (235/2953) who were previously

seronegative became seropositive. Further longitudinal analysis is pending and will be reported separately.

**Table 5** Comparison of SARS-CoV-2 seroprevalence October 2020 and April 2021, by hospital

| Participant characteristics   |                                       | St James's Hospital |        |        | University Hospital Galway |        |        | Both hospitals |        |        |
|-------------------------------|---------------------------------------|---------------------|--------|--------|----------------------------|--------|--------|----------------|--------|--------|
|                               |                                       | %                   | %      | %      | %                          | %      | %      | %              | %      |        |
|                               |                                       | Oct-20              | Apr-21 | change | Oct-20                     | Apr-21 | change | Oct-20         | Apr-21 | change |
| <b>Overall seroprevalence</b> |                                       | 15                  | 21     | 6.2    | 4.1                        | 13     | 8.8    | 10             | 18     | 7.7    |
| <b>Age groups (years)</b>     | 18-29                                 | 20                  | 24     | 4.3    | 4.7                        | 20     | 15.1   | 13             | 22     | 9.5    |
|                               | 30-39                                 | 15                  | 20     | 5.1    | 6                          | 15     | 8.9    | 10             | 18     | 7.9    |
|                               | 40-49                                 | 13                  | 19     | 6.4    | 3.5                        | 8.5    | 5.0    | 8.2            | 15     | 6.5    |
|                               | 50-59                                 | 13                  | 21     | 8.1    | 1.5                        | 10     | 8.6    | 7.7            | 17     | 8.9    |
|                               | Over 60                               | 17                  | 23     | 5.5    | 2.7                        | 8.4    | 5.7    | 9.9            | 16     | 6.1    |
| <b>Sex</b>                    | Female                                | 15                  | 21     | 5.7    | 3.5                        | 12     | 8.3    | 9.4            | 17     | 7.5    |
|                               | Male                                  | 16                  | 23     | 6.8    | 6.3                        | 17     | 10.5   | 12             | 20     | 8.3    |
| <b>Ethnicity</b>              | Irish                                 | 13                  | 19     | 6.2    | 3.7                        | 11     | 7.7    | 8.6            | 16     | 7.1    |
|                               | Any other white background            | 17                  | 22     | 4.8    | 6.3                        | 17     | 11.1   | 11             | 20     | 8.7    |
|                               | Asian background                      | 24                  | 26     | 2.0    | 7.1                        | 20     | 13.1   | 19             | 25     | 5.7    |
|                               | African or any other black background | 23                  | 42     | 19     | 2.1                        | 21     | 18.7   | 14             | 33     | 19     |
|                               | Other                                 | 13                  | 26     | 13     | -                          | 19     | -      | 6.9            | 23     | 16     |
| <b>Country of birth</b>       | Ireland                               | 13                  | 19     | 6.1    | 3.9                        | 11     | 7.4    | 8.7            | 16     | 6.9    |
|                               | United Kingdom                        | 16                  | 19     | 2.7    | 3.7                        | 12     | 8.1    | 9.3            | 15     | 5.6    |
|                               | India                                 | 23                  | 27     | 3.7    | 8.2                        | 24     | 15.3   | 18             | 26     | 7.9    |
|                               | Philippines                           | 27                  | 27     | -0.2   | 8.0                        | 6.3    | -1.8   | 25             | 25     | 0.2    |
|                               | Poland                                | 29                  | 31     | 1.8    | 6.3                        | 20     | 14     | 14             | 24     | 9.5    |
|                               | USA                                   | 14                  | 19     | 5.0    | -                          | 21     | -      | 5.0            | 20     | 15     |
|                               | Other                                 | 16                  | 28     | 12     | 4                          | 28     | 23.5   | 10             | 25     | 15     |
|                               |                                       |                     |        |        |                            |        |        |                |        |        |
| <b>Education</b>              | Primary                               | 15                  | 35     | 20     | 0.0                        | 0.0    | 0.0    | 14             | 32     | 18     |
|                               | Secondary                             | 13                  | 26     | 13     | 3.0                        | 14     | 11     | 8.9            | 22     | 13     |
|                               | Third level                           | 18                  | 24     | 5.5    | 4.3                        | 14     | 9.5    | 11             | 19     | 8.3    |
|                               | Post-graduate                         | 14                  | 17     | 3.0    | 4.1                        | 12     | 7.6    | 9.0            | 15     | 5.7    |
| <b>Role</b>                   | Admin                                 | 10                  | 16     | 5.9    | 1.2                        | 7.7    | 6.5    | 6.0            | 13     | 6.6    |
|                               | Medical/dental                        | 14                  | 15     | 1.4    | 6.9                        | 17     | 10.2   | 10             | 16     | 6.3    |
|                               | Nursing/ midwifery                    | 21                  | 26     | 4.6    | 4.7                        | 14     | 9.7    | 13             | 21     | 7.9    |

|   |  |      |     |      |      |     |       |      |     |     |
|---|--|------|-----|------|------|-----|-------|------|-----|-----|
|   | Allied health                          | 10   | 15  | 4.5  | 2.5  | 6.7 | 4.2   | 6.7  | 11  | 4.6 |
|   | General support                        | 12   | 25  | 13   | 1.7  | 17  | 15.5  | 7.6  | 22  | 15  |
|   | Health care assistant                  | 27   | 39  | 12   | 6.2  | 21  | 14.3  | 18   | 32  | 14  |
|   | Other                                  | 11   | 7.4 | -3.6 | 1.4  | 12  | 10.4  | 5.5  | 9.5 | 4.0 |
| <b>Lives with</b>                           | Alone                                  | 8.2  | 16  | 7.4  | 3.1  | 10  | 6.7   | 5.9  | 13  | 7.2 |
|   | With others                            | 16   | 22  | 5.7  | 4.2  | 13  | 9.0   | 10   | 18  | 8.1 |
|   | Missing                                | 11   | 38  | 27   | -    | -   | -     | 9.1  | 27  | 18  |
| <b>Lives with HCW</b>                       | Yes                                    | 21   | 25  | 4.2  | 4.9  | 16  | 11.6  | 13   | 22  | 8.6 |
|   | No                                     | 13   | 19  | 6.0  | 3.8  | 11  | 7.5   | 8.5  | 16  | 7.3 |
|   | Missing                                | 17   | 25  | 8.0  | 2.1  | 10  | 8.1   | 9.9  | 18  | 7.7 |
| <b>Daily contact with COVID-19 patients</b> | Contact with COVID-19 patients         | 21   | 27  | 6.0  | 7.1  | 17  | 9.7   | 15   | 23  | 8.3 |
|   | Contact with patients without COVID-19 | 17   | 22  | 4.5  | 4.6  | 15  | 10.3  | 11   | 19  | 7.5 |
|   | No patient contact                     | 9.5  | 16  | 6.1  | 1.3  | 6.1 | 4.8   | 5.9  | 12  | 5.8 |
| <b>Previous COVID-19 symptoms</b>           | No symptoms                            | 5.8  | 7.7 | 1.9  | 1.3  | 3.6 | 2.3   | 3.2  | 5.8 | 2.6 |
|   | Had symptoms                           | 23   | 37  | 14   | 7.5  | 28  | 21    | 17   | 34  | 17  |
| <b>Previous positive COVID-19 PCR test</b>  | No                                     | 6.8  | 7.8 | 1.0  | 1.5  | 2.4 | 0.9   | 4.2  | 5.5 | 1.3 |
|   | Yes                                    | 94.9 | 84  | -11  | 97.3 | 78  | -19.1 | 95.4 | 82  | -14 |



## Discussion

### Participation and demographics

Our participants were similar in age and sex to those in other European studies (40) (41) (42). The participation rate was slightly lower for PRECISE 2 compared to PRECISE 1 (56% vs 64%). Overall, however, this is still a good uptake rate for an institutional opt-in study, comparable to other European studies (43) and included representation from all HCW groups, including the traditionally harder-to-reach groups such as general support staff and healthcare assistants, who may not engage as frequently with hospital communications platforms. Importantly, representation was similar across staff roles for PRECISE 1 and PRECISE 2, and overall participant demographics were similar in both studies, and therefore the data are likely to be comparable.

### Overall seroprevalence

The overall seroprevalence of antibodies to SARS-CoV-2 in SJH rose from 15% in October 2020 to 21% in April 2021. The overall seroprevalence of antibodies to SARS-CoV-2 in UHG rose from 4.1% in October 2020 to 13% in April 2021. The combined overall seroprevalence for the two hospitals increased from 10% in October 2020 to 18% in April 2021. To the best of our knowledge there are no published studies evaluating SARS-CoV-2 seroprevalence in HCW in Europe in 2021.

In terms of the difference in seroprevalence between the two hospitals, we believe this to be related to local community incidence, to social and demographic factors, and to local work practices. The difference in seroprevalence between the two sites primarily reflects

the difference in community incidence, with a corresponding higher seroprevalence seen in the staff SJH, in the more densely populated capital city of Dublin, which has had higher community incidence throughout the pandemic thus far. Other studies have also shown community incidence to be one of the main factors impacting risk to HCW (44) (45). The rise in seroprevalence at both sites reflects the magnitude of the third wave of the pandemic at both sites. The relatively higher increase in seroprevalence in UHG compared to SJH likely reflects the fact that the community incidence in the Galway area approached that of the Dublin incidence during this third COVID-19 wave (30). A higher community incidence means that HCW are more likely to be exposed by the nature of their work which involves direct contact with other people, both patients and other HCW. While this risk disproportionately affected those with closer patient contact, the risk to HCW was higher than in the community, even for those who reported little or no patient contact.

The difference in overall seroprevalence was also likely to have been impacted by differences in hospital infrastructure, work-practices, bed-flow management, and the differing demographic and social factors by HCW role at each site. Broad work-place practices in both hospitals have been similar throughout the pandemic, including ward-based medical teams and universal use of face-masks. There were no issues with personal protective equipment (PPE) availability in either of the hospitals involved in our study at any stage thus far during the pandemic, and where staff were re-deployed to improve the hospital's capacity to deal with the outbreak, staff were not deployed to areas that would have been outside of their scope of practice, and all staff had training on the correct use of PPE. Both hospitals experienced multiple outbreaks during the 3<sup>rd</sup> wave of the pandemic, however the absence of real time genomic sequencing precludes identifying the role of



hospital outbreaks in influencing the overall seroprevalence. It is also difficult to identify the contribution of the workplace versus the community/ household/ social factors to the attributable risk to HCW. It is likely that many of these transmissions took place in the household, where higher attack rates are seen (46). It is also unclear as to the timing of arrival of different VOCs to each location, and the potential impact of this on changes in overall seroprevalence.

The overall seroprevalence was higher than the European average of 8.5% in a recently published meta-analysis (47), however this meta-analysis only took into account studies published up until August 2020. Individual studies across Europe in the first year of the pandemic showed a wide range of SARS-CoV-2 seroprevalence among HCW (1-45%) (40) (42) (48) (49) (50) (51). A recently published large study in Italian showed a seroprevalence of 12% in HCW, however the serological testing was conducted in April and May 2020 (43). Assumably the seroprevalence amongst HCW has risen across the rest of Europe since then, as our study shows it has in Ireland, however there are no published data for comparison.

Our study compared seroprevalence among the same HCW group at two points in time six months apart. A German study evaluated seroprevalence at 3 points in time, all in 2020, and found low seroprevalence among HCW at all three points in time (52). A Japanese study found much lower seroprevalence rates both before and after their second wave of the pandemic (<1% at both points in time, also both in 2020) (53).

#### Seroprevalence by role and type of patient contact

Daily contact with patients with known/suspected COVID-19 infection was associated with higher seroprevalence, followed by daily contact with patients without known or suspected

COVID-19 infection. Having little or no patient contact carried the lowest seroprevalence. This reflected the findings of PRECISE 1 and has also been shown by other studies (54) (55) (56). In terms of working role, being a nurse or a HCA carried a higher aRR, likely also reflecting the close patient contact involved in performing these roles. The highest seroprevalence was seen amongst HCAs; this was also a key finding of PRECISE 1, and this seroprevalence almost doubled over the six months between PRECISE 1 and 2. This finding has also been shown in other large European studies (43).

The seroprevalence among general support staff (which includes domestic and catering staff, maintenance, security and porters) trebled from PRECISE 1 to PRECISE 2, giving them the second highest seroprevalence of any working role in PRECISE 2. This increase was in both locations and was across all groups in this category (Table 2f, Annex). This was possibly related to outbreaks amongst these staff groups, though it was not clear whether these outbreaks were related to the workplace or not. There may be improper compliance with use of PPE, and fatigue with ICP as the pandemic has progressed. There are likely to also be other social factors involved that our study was not designed to assess.

The seroprevalence amongst medical staff showed one of the largest increases in UHG (from 6.9% to 17%) (Table 5). This may be related to social practices; many doctors working in UHG are not from Galway, and live and socialise together (in UHG 53% of doctors reported living with other HCW compared to 43% in SJH). In SJH, the smallest relative increase between PRECISE 1 and PRECISE 2 (from 14% to 15%) was amongst the medical staff. This resulted in medical staff having the joined-lowest seroprevalence of any role group in SJH by April 2021. Although the overall uptake among medical staff was similar to PRECISE 1, including of those who were seropositive in PRECISE 1, it is possible that medical staff who

knew they had already had COVID-19 infection were less interested in participating in the study and availing of serology testing. Other studies have shown that medical staff are more likely to get vaccinated promptly against other infectious diseases (57), including influenza; occupational health data from SJH in 2019 showed that 60% of doctors received the influenza vaccine compared to 23% of nursing staff. In our study, 93% of doctors had completed vaccination and 99% (684/692) had started vaccination, compared to only 81% of all staff having completed vaccination by the time of the study. This may indicate that doctors sought vaccination quicker than other role groups after its roll-out but does not explain the difference between the two hospitals. Overall this data shows that medical staff in SJH were less likely to be infected, and more likely to be diagnosed when they did get infected.

#### Previous symptoms and testing

Only 82% of participants with previous PCR-confirmed infection had detectable antibodies, compared to 95% of PRECISE 1 participants. This may be related to antibody waning over time for those in whom the reported infection occurred in the first wave of the pandemic. There may also be participants who were vaccinated, and therefore the anti-S antibody detected in PRECISE 2, assumed to be due to vaccination, may have been present before vaccination in response to previous infection. The longitudinal analysis of those participants common to PRECISE 1 and 2 below contains more detail on loss of antibody in those who were seropositive in PRECISE 1.

Nineteen percent of participants with detectable antibodies reported never having experienced symptoms that were consistent with infection with COVID-19, compared to 16% in PRECISE 1. This falls within the broad range reported by other studies (58). Those

who had a symptomatic infection had a higher rate of antibody positivity than those who had an asymptomatic infection (90% versus 51%). This is also in keeping with other published data (59).

Over a quarter of participants reported having COVID-19 like symptoms at some stage but never having a positive PCR. This highlights the potential overlap in symptoms with other circulating viruses, including rhinoviruses which were circulating widely over the winter of 2020/21 in Ireland, and is a reminder of the impossibility of clinically excluding COVID-19 infection in HCW with symptoms, including in those with only mild symptoms, especially over the winter period. It also highlights the complexity involved in developing case definitions and testing guidelines.

### Undiagnosed infections

In both hospitals, the seroprevalence was higher than the known PCR-confirmed diagnoses of COVID-19 infection of the same timeframe (21% vs 18% in SJH, and 13% vs 9.2% in UHG) though this gap was narrower than for PRECISE 1, assumably due to increased awareness and testing. Twenty-six percent of the infections in our study were undiagnosed, with 4.6% of all participants having had an undiagnosed infection. Almost half of these undiagnosed infections were asymptomatic (which was significantly higher than the rate of asymptomatic infections in those who had diagnosed COVID-19 infection). This proportion of undiagnosed infection has decreased from 39% in PRECISE 1, however still a quarter of infections had been undiagnosed despite both hospitals having onsite PCR testing available to HCW with symptoms or close contact with a confirmed case of COVID-19 from mid-March 2020.

Although the majority of these infections were associated with only mild symptoms, it is still

possible that these undiagnosed HCW were working during the infectious period, with potential for onwards transmission to patients and other staff members if proper use of PPE and other infection prevention and control (IPC) measures were not strictly adhered to. Easy access to testing, early detection of infection, and ongoing adherence to standard infection control precautions at all times, as well as the appropriate use of PPE including face masks in the hospital setting, irrespective of symptoms remain important (60). This finding also supports the recommendation for screening of asymptomatic staff, including vaccinated staff in certain when a patient case of hospital-acquired infection, or hospital outbreak of infection with COVID-19 occurs. The exact role and methodology of routine asymptomatic screening, either widespread or in certain HCW, also remains to be defined.

#### Risk factors for antibody positivity

The main risk factors identified to be statistically significantly associated with antibody positivity (in decreasing order of aRR) were being a HCA, being of Black ethnicity, working in SJH, having secondary level education as opposed to post-graduate level education, being a nurse, having daily contact with patients (especially those known or suspected to have COVID-19 infection), being age 18-29, living with other HCW and being male. When broken down by hospital, the main risk factors identified to be significantly associated with SARS-CoV-2 antibody positivity differed. Seroprevalence by age and sex were similar to previously published literature, and similar to the findings of PRECISE 1 (1) (2) (47). Similar findings of increased risk direct patient contact, the role of HCA, and working with patients with COVID-19 infection have also been reported in the literature (42) (47) (61) (62).

Apart from the changes in seroprevalence by role discussed above, there were two main new findings on multivariate analysis from PRECISE 2 in comparison to PRECISE 1. Firstly,

level of education emerged as an independent risk factor for seropositivity, with lower level of education being associated with higher seropositivity. Lower socio-economic status has been previously noted to correlate with increased risk of COVID-19 infection, and increased risk of poor clinical outcomes (63) (64). It is also associated with HCW role.

The second notable new finding was a change in the seropositivity by ethnic group; the seroprevalence amongst those of Black ethnicity trebled (from 14% (16/113) to 43% (39/117), for an aRR of 1.7 (95% CI 1.3-2.2,  $p < .001$ ). They were also more likely to be asymptomatic, but not more likely to have an undiagnosed infection. The seroprevalence amongst those of Romanian nationality was also high for both hospitals combined, though numbers were small. Those of Asian ethnicity had a higher risk of seropositivity in PRECISE 1, but this finding was no longer significant in PRECISE 2. Both of these ethnic groups, as well as other minority ethnic groups which were likely under-represented in our study, have been shown to have increased risk in other studies (47) (65) (66) (67). There are likely to be social factors contributing to these ethnicity-related findings in both hospitals that our study did not measure.

Living with other HCW carried an increased risk for seropositivity, similar to our previous findings. This supports the theory that a proportion of the HCW contracting COVID-19 are doing so in their home environment. This finding was stronger in SJH than in UHG, where the community incidence was higher and the density of shared living space is also likely to be higher due to smaller spaces and more expensive accommodation in the capital city. Other studies have found correlation between size of household and antibody positivity (40) as well as higher risk of COVID-19 with a known household contact (68). To the best of our

knowledge ours is the first study to comment on a significant risk of antibody positivity in HCW living with other HCW. This finding was common to both PRECISE 1 and 2.

#### Antibody response to vaccination

Most participants were either fully or partially vaccinated. All fully vaccinated participants, and the majority of partially vaccinated participants, had detectable anti-S antibodies. Other studies have also shown high rates of seropositivity after both first and second dose vaccination (36) (69) (70) .

There were less breakthrough infections in those fully vaccinated than in those partially vaccinated (13% versus 0.6% of participants reported infection post first and second vaccine respectively), despite the fact that almost all of these participants had detectable antibodies. The 23 breakthrough infections, in 0.6% of the fully vaccinated study population, are in keeping with the rate of breakthrough infections experienced internationally (71).

These breakthrough infections serve as a reminder that vaccination does not prevent infection acquisition, even in the setting of confirmed serological response to vaccination.

Most of those with breakthrough infections had no symptoms, in keeping with the literature on vaccine effectiveness in reduction of severe symptoms and hospitalisation (19) (72)

however the numbers are too small for any statistical comparison with symptoms in those who were unvaccinated. It would be prudent for all IPC measures to remain in place in the hospital setting, including for vaccinated HCW, while research is ongoing into the effects of vaccination on infection acquisition and onwards transmission, including with VOCs.

Vaccinated HCW should not be exempt from measures discussed above in relation to minimising the rate of undiagnosed infections (access to testing, adherence to standard IPC

precautions and inclusion in screening of asymptomatic staff in the case of a hospital outbreak).

It is also notable that of the 23 confirmed infections in fully vaccinated participants, only 6 of these participants had developed anti-N antibodies in response to their infection. Of the 17 that were anti-N negative, median number of days between PCR positivity and sampling mid-point was 52 (range 9-67) so it is surprising that the majority of these had not mounted an anti-N antibody response (73). This low number of seroconversions might suggest that anti-N antibodies as a marker of natural infection post vaccination are unreliable. It raises the questions of whether the pre-existing spike antibodies alter the way the virus interacts with the immune system, with less production of anti-N antibodies. The numbers are very small but further research is warranted as this would be a very important point as we try to measure seroconversion and seroprevalence going forward in a post-vaccination era. To the best of our knowledge there are no published data to date commenting on this. Of the 17 that were anti-N negative, median number of days between PCR positivity and sampling mid-point was 52 (range 9-67) so it is surprising that the majority of these had not mounted an anti-N antibody response (73). This low number of seroconversions might suggest that anti-N antibodies may be insensitive as a marker of natural infection post vaccination. It is possible that early viral neutralisation, perhaps even at mucosal surfaces, might modify the natural humoral response and limit the development of anti-N antibodies. Studies are continuing to rely on anti-N as a marker of seropositivity related to natural infection, including in vaccinated individuals (74). To the best of our knowledge there are no published data to date that have identified a comparative reduction in anti-N seroconversion following natural infection in vaccinated individuals. Further research of individuals with well-defined



vaccine breakthrough infections are required, as this information will be critical in determining how best to assess seroprevalence in vaccinated cohorts.

### Sustained Antibody Response over six-months

Ninety percent of participants who were common to both studies, and were seropositive in PRECISE 1, still had antibodies at the time of PRECISE 2. The duration of antibody response in the literature is varied (11) (12), and further studies are still needed to directly correlate sustained antibody positivity with protection from re-infection, especially as the pandemic progresses and further VOCs emerge.

### **Limitations**

This study has several limitations. Firstly, information on COVID-19 symptoms and PCR test results were self-reported and thus could be biased. Secondly, although the uptake rate was good for an opt-in study, it was lower than the uptake for PRECISE 1; declining interest in research in the area of COVID-19 is a natural phenomenon as the pandemic progresses. Many staff at this point in time already knew they had been infected and therefore may have less interest in participating and availing of serology testing. Most staff had been vaccinated and therefore may also have a degree of comfort that produces less interest in knowing their antibody status. PRECISE 2 took place during the third wave of the pandemic in Ireland, which was the largest in magnitude and the longest. Other limitations include that WGS testing results were not available, particularly for those infected after full vaccination, and also that information on biological factors, e.g. co-morbidities, was not available. Although the communication strategy was an important part of the recruitment process, the study took part during our third wave of the pandemic, during Level 5

restrictions - the highest level of COVID-19 national restrictions - and therefore also relied heavily on engagement with information technology (IT) platforms (email, messenger groups, hospital intranet) and less on face-to-face announcements. Thirdly, as with all opt-in studies, there may be a selection bias. Those who had been vaccinated may have had less interest in participating due to less curiosity about their own serostatus, and therefore we may have underestimated the overall vaccination status of the workforce. Conversely, those who were unvaccinated may have had a fear of having to announce their vaccine-status to the study team, despite results not being linked to occupational health records, and those who had been vaccinated may have been more likely to participate as they may be more likely to have health seeking behavior. The online consent process, questionnaire, and blood test booking system risks exclusion of those who are less literate in IT. This was identified as a potential limitation from the start, and attempts were made to mitigate this selection bias. Multilanguage information and plain English were used, and groups identified as potentially at risk of exclusion on this basis were targeted directly for inclusion in the study, with small-group sessions to aid consent and questionnaire completion and walk-in clinics for phlebotomy. We do not have individual level information on reasons for non-participation, or socio-demographic status of non-participants for comparison, but level of uptake by professional role was deemed to be representative of the hospital HCW population in both hospitals. The absence of real time genomic sequencing data precludes identifying the role of hospital outbreaks in influencing the overall seroprevalence, as well as drawing any definite conclusions regarding attributable risk to the workplace versus the community for HCW.

Detection of anti-spike antibody in conjunction with a self-reported history of vaccination was considered to be as a response to vaccination. It is possible that some of these participants may have detectable anti-spike antibody related to natural infection; these were not counted when assessing overall seroprevalence of presumed past infection, and therefore this overall seroprevalence may be an underestimate. Seroprevalence could also be underestimated because recent infection could be missed as several days are required for seroconversion of SARS-CoV-2 infection. Finally, some false negatives and false positives are expected with all laboratory tests. When the estimate of seroprevalence is adjusted using the manufacturer's stated specificity of 99.8% and sensitivity of 99.5%, (the seroprevalence does not change (18%; 95% CI 17% - 19%).

### **Conclusion and Recommendations**

This study is a unique comparison between two hospitals in areas of differing community incidence over time, in which IPC measures were the same. The overall seroprevalence of antibodies to SARS-CoV-2 of 21% in SJH and 13% in UHG reflect the difference in community incidence in each area and the difference in rates of confirmed infections among the HCW of each hospital. Risk was higher in the hospital situated in a higher density area with higher community incidence throughout the COVID-19 pandemic. The rise in seroprevalence from 15% to 21% in SJH in and from 4.1% to 13% in UHG between October 2020 and April 2021 reflect the magnitude of the third wave of the pandemic in each location. This data compounded the findings of PRECISE 1, highlighting the local community incidence as one of the most significant risk factors for acquisition of COVID-19 infection in HCW. It is also likely that social and demographic factors, and local work practices influenced the overall seroprevalence. The lack of real time genomic sequencing precludes identifying the role of

hospital outbreaks in influencing the overall seroprevalence, as well as drawing conclusions regarding attributable risk to the healthcare environment versus the community or household.

Other risk factors common to both PRECISE 1 and 2 included demographic risk factors (younger age group, male and Black or Asian ethnic group) and work-place related risk factors representing close patient contact, including the role of HCA. We identified living with other HCW as an independent risk factor for seropositivity in both studies; to the best of our knowledge there is no other published literature commenting specifically on this risk factor. The other risk factors that we identified are consistent with the published literature.

The comparison between PRECISE 1 and 2 highlights similar features throughout the pandemic, but also the changing epidemiology with different waves. The main differences in the findings of PRECISE 1 and PRECISE 2 were related to role, ethnicity and level of education, showing that certain risks may change with different waves of the pandemic. The large increase in the seropositivity among general support staff and higher seroprevalence among doctors in UHG compared to SJH are difficult to fully explain and may relate to social factors. While both studies highlighted minority ethnic groups as more at risk, the group highlighted in each study was different. Level of education, which has been shown internationally to play a role, emerged as a new significant finding in PRECISE 2. This, coupled with the findings of risk related to ethnicity, may suggest that, even a year and a half into the pandemic, some groups may not have been adequately reached by messaging and education, and ongoing efforts need to be made in this regard.

The degree of previously undiagnosed infections highlights the need for ongoing universal adherence to infection control guidance including the use of appropriate PPE in the hospital

setting, as well as the importance of early case detection. It is essential that HCW have easy access to testing, even with mild or no symptoms, and even in the post vaccination setting. (75). We recommend ongoing risk assessment in the setting of a hospital outbreak, and where indicated, screening of HCW, including those without symptoms, and including those who are vaccinated.

Ninety percent of those who were anti-body positive (anti-N) in October 2020 and took part in April 2021 were remained positive (anti-N). Further research is needed to understand the anti-N seroconversion following natural infection in vaccinated individuals to inform optimal assessment of seroprevalence in vaccinated cohorts.

The antibody response to vaccination is reassuring, however we did show confirmed infection in a small minority of fully vaccinated participants; further studies are needed to correlate serological response with functional immunity. Formal vaccine effectiveness studies are needed to monitor how effective COVID-19 vaccines are in hospital HCW and to estimate duration of protection from infection, particularly with the ongoing emergence of variants of concern. With emerging evidence of reduction in transmission from vaccinated individuals, the authors strongly endorse immediate vaccination of all HCW. Messaging to HCW regarding the role and limits of vaccination need to be clear and should include the ongoing risk of infection and transmission. Ongoing adherence to all infection prevention and control standards in the healthcare setting and household are paramount. Easy access to testing of HCW with symptoms (including mild symptoms and including those who are vaccinated) and in the setting of close contact with a confirmed case of COVID-19 infection should continue, and vaccinated HCW with PCR-confirmed COVID-19 infection should be actively assessed to advance understanding of the reasons for breakthrough infection. This

should include whole genome sequencing (WGS) of the virus from HCW with breakthrough infection and/or of virus from index cases identified by follow-up.

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### **Conflict of Interest**

None of the authors have any conflicts of interest to declare.

### **Data Availability Statement**

This dataset is not available to the public for ethical reasons of data protection as certain individuals may be identifiable from the data.

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## Annex

**Table A** Response rate by HCW type, PRECISE 2, April 2021

| HCW role              | St James's Hospital |             |            | University Hospital |             |            | Combined response |             |            |
|-----------------------|---------------------|-------------|------------|---------------------|-------------|------------|-------------------|-------------|------------|
|                       | N                   | n           | %          | N                   | n           | %          | N                 | n           | %          |
| Admin                 | 693                 | 403         | 58%        | 639                 | 273         | 43%        | 1332              | 676         | 51%        |
| Medical/dental        | 621                 | 357         | 57%        | 814                 | 356         | 44%        | 1435              | 713         | 50%        |
| Nursing/ midwifery    | 1802                | 1097        | 61%        | 1689                | 794         | 47%        | 3491              | 1,891       | 54%        |
| Allied health         | 742                 | 612         | 82%        | 648                 | 432         | 67%        | 1390              | 1,044       | 75%        |
| General support       | 412                 | 243         | 59%        | 240                 | 122         | 51%        | 652               | 365         | 56%        |
| Health care assistant | 422                 | 179         | 42%        | 316                 | 112         | 35%        | 738               | 291         | 39%        |
| Other                 | -                   | 54          |            | -                   | 51          |            | -                 | 105         |            |
| <b>Total</b>          | <b>4692</b>         | <b>2945</b> | <b>63%</b> | <b>4346</b>         | <b>2140</b> | <b>49%</b> | <b>9038</b>       | <b>5085</b> | <b>56%</b> |

**Table B** Comparison of all staff and study participants in St James's Hospital by healthcare worker role, PRECISE 2, April 2021

| HCW role              | St James's Hospital all |             | St James's Hospital |             | Difference  |          |
|-----------------------|-------------------------|-------------|---------------------|-------------|-------------|----------|
|                       | N                       | %           | n                   | %           | n           | %        |
| Admin                 | 693                     | 15%         | 403                 | 14%         | 290         | -1.1%    |
| Medical/dental        | 621                     | 13%         | 357                 | 12%         | 264         | -1.1%    |
| Nursing/ midwifery    | 1802                    | 38%         | 1097                | 37%         | 705         | -1.2%    |
| Allied health         | 742                     | 16%         | 612                 | 21%         | 130         | 5.0%     |
| General support       | 412                     | 8.8%        | 243                 | 8.3%        | 169         | -0.5%    |
| Health care assistant | 422                     | 9.0%        | 179                 | 6.1%        | 243         | -2.9%    |
| Other                 | -                       | -           | 54                  | 1.8%        | -           | -        |
| <b>Total</b>          | <b>4692</b>             | <b>100%</b> | <b>2945</b>         | <b>100%</b> | <b>1747</b> | <b>-</b> |

**Table C** Comparison of all staff and study participants in University Hospital Galway by healthcare worker role, PRECISE 2, April 2021

| HCW role           | University Hospital |     | University Hospital |     | Difference |       |
|--------------------|---------------------|-----|---------------------|-----|------------|-------|
|                    | N                   | %   | n                   | %   | n          | %     |
| Admin              | 639                 | 15% | 273                 | 13% | 366        | -1.9% |
| Medical/dental     | 814                 | 19% | 356                 | 17% | 458        | -2.0% |
| Nursing/ midwifery | 1689                | 39% | 794                 | 37% | 895        | -1.6% |

|                              |      |      |      |      |      |       |
|------------------------------|------|------|------|------|------|-------|
| <b>Allied health</b>         | 648  | 15%  | 432  | 20%  | 216  | 5.3%  |
| <b>General support</b>       | 240  | 5.5% | 122  | 5.7% | 118  | 0.2%  |
| <b>Health care assistant</b> | 316  | 7.2% | 112  | 5.2% | 204  | -2.0% |
| <b>Other</b>                 | -    | -    | 51   | 2.4% | -    | -     |
| <b>Total</b>                 | 4364 | 100% | 2140 | 100% | 2224 | -     |

**Table D** Comparison of all staff and study participants by healthcare worker role, PRECISE 2, April 2021

| HCW role                     | All invited staff |      | All study participants |      | Difference |       |
|------------------------------|-------------------|------|------------------------|------|------------|-------|
|                              | N                 | %    | n                      | %    | n          | %     |
| <b>Admin</b>                 | 1332              | 15%  | 676                    | 13%  | 656        | -1.5% |
| <b>Medical/dental</b>        | 1435              | 16%  | 713                    | 14%  | 722        | -1.9% |
| <b>Nursing/ midwifery</b>    | 3491              | 39%  | 1,891                  | 37%  | 1600       | -1.5% |
| <b>Allied health</b>         | 1390              | 15%  | 1,044                  | 21%  | 346        | 5.1%  |
| <b>General support</b>       | 652               | 7.2% | 365                    | 7.2% | 287        | 0.0%  |
| <b>Health care assistant</b> | 738               | 8.2% | 291                    | 5.7% | 447        | -2.5% |
| <b>Other</b>                 |                   | -    | 105                    | 2.1% | -          | -     |
| <b>Total</b>                 | 9028              | 100% | 5085                   | 100% | 3943       | -     |

**Table E** Characteristics of HCWs with SARS-CoV-2 seropositivity (n=898), by hospital, PRECISE 2, April 2021

| Participant characteristics                          |   | St James's<br>Hospital Dublin |       | University<br>Hospital<br>Galway |      | Both Hospitals |       |
|--|---|-------------------------------|-------|----------------------------------|------|----------------|-------|
|  |   | n                             | %     | n                                | %    | n              | %     |
| <b>Overall</b>                                       |   | 623                           | 21%   | 275                              | 13%  | 898            | 18%   |
| <b>Median age (IQR)</b>                              |   | 39 (29-49)                    |       | 35 (27-44)                       |      | 38 (29-48)     |       |
| <b>Age groups<br/>(years)</b>                        | 18-29                                     | 159                           | 26%   | 90                               | 33%  | 249            | 28%   |
|  | 30-39                                     | 154                           | 25%   | 84                               | 31%  | 238            | 27%   |
|  | 40-49                                     | 157                           | 25%   | 51                               | 19%  | 208            | 23%   |
|  | 50-59                                     | 119                           | 19%   | 39                               | 14%  | 158            | 18%   |
|  | Over 60                                   | 34                            | 5.5%  | 11                               | 4.0% | 45             | 5.0%  |
| <b>Sex</b>   | Female                                    | 471                           | 76%   | 198                              | 72%  | 669            | 74%   |
|  | Male                                      | 152                           | 24%   | 77                               | 28%  | 229            | 26%   |
| <b>Ethnicity</b>                                     | Irish                                     | 401                           | 64%   | 194                              | 71%  | 595            | 66%   |
|  | Any other white background                | 56                            | 9.0%  | 38                               | 14%  | 94             | 10%   |
|  | Asian background                          | 122                           | 20%   | 26                               | 9.5% | 148            | 16%   |
|  | African/other black background            | 29                            | 4.7%  | 10                               | 3.6% | 39             | 4.3%  |
|  | Other                                     | 15                            | 2.4%  | 7                                | 2.5% | 22             | 2.4%  |
| <b>Country of<br/>birth</b>                          | Ireland                                   | 386                           | 62%   | 181                              | 66%  | 567            | 63%   |
|  | United Kingdom                            | 25                            | 4.0%  | 19                               | 6.9% | 44             | 4.9%  |
|  | India                                     | 60                            | 10%   | 16                               | 5.8% | 76             | 8.5%  |
|  | Philippines                               | 53                            | 8.5%  | 1                                | 0.4% | 54             | 6.0%  |
|  | Poland                                    | 8                             | 1.3%  | 12                               | 4.4% | 20             | 2.2%  |
|  | USA                                       | 4                             | 0.6%  | 7                                | 2.5% | 11             | 1.2%  |
|  | Romania                                   | 12                            | 1.9%  | 3                                | 1.1% | 15             | 1.7%  |
|  | Nigeria                                   | 18                            | 2.9%  | 1                                | 0.4% | 19             | 2.1%  |
|  | Other                                     | 57                            | 9.1%  | 35                               | 13%  | 92             | 10%   |
| <b>Education</b>                                     | Primary                                   | 7                             | 1.1%  | 0                                | 0.0% | 7              | 0.8%  |
|  | Secondary                                 | 105                           | 17%   | 28                               | 10%  | 133            | 15%   |
|  | Third level                               | 301                           | 48%   | 133                              | 48%  | 434            | 48%   |
|  | Post-graduate                             | 210                           | 34%   | 114                              | 41%  | 324            | 36%   |
| <b>Role</b>  | Admin                                     | 64                            | 10%   | 21                               | 7.6% | 85             | 9.5%  |
|  | Medical/dental                            | 55                            | 8.8%  | 61                               | 22%  | 116            | 13%   |
|  | Nursing/ midwifery                        | 281                           | 45%   | 114                              | 41%  | 395            | 44%   |
|  | Allied health                             | 89                            | 14%   | 29                               | 11%  | 118            | 13%   |
|  | General support                           | 60                            | 10%   | 21                               | 7.6% | 81             | 9.0%  |
|  | Health care assistant                     | 70                            | 11%   | 23                               | 8.4% | 93             | 10%   |
|  | Other                                     | 4                             | 0.6%  | 6                                | 2.2% | 10             | 1.1%  |
| <b>Lives with</b>                                    | Alone                                     | 42                            | 6.7%  | 19                               | 6.9% | 61             | 6.8%  |
|  | With others                               | 578                           | 92.8% | 256                              | 93%  | 834            | 92.9% |
|  | Missing                                   | 3                             | 0.5%  | 0                                | 0.0% | 3              | 0.3%  |
| <b>Lives with<br/>HCW</b>                            | Yes                                       | 234                           | 38%   | 106                              | 39%  | 340            | 38%   |
|  | No  | 376                           | 60%   | 164                              | 60%  | 540            | 60%   |
|  | Missing                                   | 13                            | 2.1%  | 5                                | 1.8% | 18             | 2.0%  |
| <b>Daily contact<br/>with COVID-<br/>19 patients</b> | Contact with COVID-19 patients            | 196                           | 31%   | 69                               | 25%  | 265            | 30%   |
|  | Contact with patients without<br>COVID-19 | 293                           | 47%   | 170                              | 62%  | 463            | 52%   |
|  | No patient contact                        | 134                           | 22%   | 36                               | 13%  | 170            | 19%   |

|   |                       |     |      |     |      |     |      |
|---|-----------------------|-----|------|-----|------|-----|------|
| <b>Previous COVID-19 symptoms</b>                     | No symptoms           | 121 | 19%  | 48  | 17%  | 169 | 19%  |
|   | Had symptoms          | 502 | 81%  | 227 | 83%  | 729 | 81%  |
|   | Missing               | 0   | 0.0% | 0   | 0.0% | 0   | 0.0% |
| <b>Severity of symptoms</b>                           | No symptoms           | 121 | 19%  | 48  | 17%  | 169 | 19%  |
|   | Mild symptoms         | 228 | 37%  | 107 | 39%  | 335 | 37%  |
|   | Significant symptoms  | 262 | 42%  | 102 | 37%  | 364 | 41%  |
|   | Severe (hospitalised) | 12  | 1.9% | 18  | 6.5% | 30  | 3.3% |
|   | Missing               | 0   | 0.0% | 0   | 0.0% | 0   | 0.0% |
| <b>Previous positive COVID-19 PCR test</b>            | No                    | 190 | 30%  | 45  | 16%  | 235 | 26%  |
|   | Yes                   | 433 | 70%  | 230 | 84%  | 663 | 74%  |
| <b>Symptoms at time of previous positive PCR test</b> | No                    | 51  | 12%  | 36  | 16%  | 87  | 13%  |
|   | Yes                   | 382 | 88%  | 194 | 84%  | 576 | 87%  |
| <b>Severity of symptoms at time of PCR test</b>       | No symptoms           | 51  | 12%  | 36  | 16%  | 87  | 13%  |
|   | Mild symptoms         | 143 | 33%  | 83  | 36%  | 226 | 34%  |
|   | Significant symptoms  | 227 | 52%  | 93  | 40%  | 320 | 48%  |
|   | Severe (hospitalised) | 12  | 2.8% | 18  | 7.8% | 30  | 4.5% |
|   | Missing               | 0   | 0.0% | 0   | 0.0% | 0   | 0.0% |



**Table 2e** Prevalence of SARS-CoV-2 seropositivity by participant characteristics, both hospitals, PRECISE 2, April 2021

| Participant characteristics |                                       | Total |     | SARS-CoV-2 seropositive |          |
|-----------------------------|---------------------------------------|-------|-----|-------------------------|----------|
|                             |                                       | N     | n   | % (95% CI)              | p-value* |
| <b>Overall</b>              |                                       | 5085  | 898 | 18 (17 - 19)            |          |
| <b>Hospital</b>             | St James's Hospital                   | 2,945 | 623 | 21 (20 - 23)            | <0.001   |
|                             | University Hospital Galway            | 2,140 | 275 | 13 (11 - 14)            |          |
| <b>Age groups (years)</b>   | 18-29                                 | 1108  | 249 | 22 (20 - 25)            | <0.001   |
|                             | 30-39                                 | 1330  | 238 | 18 (16 - 20)            |          |
|                             | 40-49                                 | 1414  | 208 | 15 (13 - 17)            |          |
|                             | 50-59                                 | 951   | 158 | 17 (14 - 19)            |          |
|                             | Over 60                               | 282   | 45  | 16 (12 - 21)            |          |
| <b>Sex</b>                  | Female                                | 3,959 | 669 | 17 (16 - 18)            | 0.008    |
|                             | Male                                  | 1,126 | 229 | 20 (18 - 23)            |          |
| <b>Ethnicity</b>            | Irish                                 | 3,798 | 595 | 16 (15 - 17)            | <0.001   |
|                             | Any other white background            | 476   | 94  | 20 (16 - 24)            |          |
|                             | Asian background                      | 599   | 148 | 25 (21 - 28)            |          |
|                             | African or any other black background | 117   | 39  | 33 (25 - 43)            |          |
|                             | Other                                 | 95    | 22  | 23 (15 - 33)            |          |
| <b>Country of birth</b>     | Ireland                               | 3,630 | 567 | 16 (14 - 17)            | <0.001   |
|                             | United Kingdom                        | 295   | 44  | 15 (11 - 20)            |          |
|                             | India                                 | 293   | 76  | 26 (21 - 31)            |          |
|                             | Philippines                           | 214   | 54  | 25 (20 - 32)            |          |
|                             | Poland                                | 85    | 20  | 24 (15 - 34)            |          |
|                             | USA                                   | 55    | 11  | 20 (10 - 33)            |          |
|                             | Romania                               | 45    | 15  | 33 (20 - 49)            |          |
|                             | Nigeria                               | 35    | 19  | 54 (31 - 71)            |          |
|                             | Other                                 | 433   | 92  | 21 (17 - 25)            |          |
| <b>Education</b>            | Primary                               | 22    | 7   | 32 (14 - 55)            | <0.001   |
|                             | Secondary                             | 609   | 133 | 22 (19 - 25)            |          |
|                             | Third level                           | 2,244 | 434 | 19 (18 - 21)            |          |
|                             | Post-graduate                         | 2,210 | 324 | 15 (13 - 16)            |          |
| <b>Role</b>                 | Admin                                 | 676   | 85  | 13 (10 - 15)            | <0.001   |
|                             | Medical/dental                        | 713   | 116 | 16 (14 - 19)            |          |
|                             | Nursing/ midwifery                    | 1,891 | 395 | 21 (19 - 23)            |          |
|                             | Allied health                         | 1,044 | 118 | 11 (9.4 - 13)           |          |
|                             | General support                       | 365   | 81  | 22 (18 - 27)            |          |
|                             | Health care assistant                 | 291   | 93  | 32 (27 - 38)            |          |
|                             | Other                                 | 105   | 10  | 10 (4.7 - 17)           |          |
| <b>Lives with</b>           | Alone                                 | 464   | 61  | 13 (10 - 17)            | 0.008    |
|                             | With others                           | 4,610 | 834 | 18 (17 - 19)            |          |
|                             | Missing                               | 11    | 3   | 27 (6.0 - 61)           |          |
| <b>Lives with HCW</b>       | Yes                                   | 1,571 | 340 | 22 (20 - 24)            | <0.001   |
|                             | No                                    | 3412  | 540 | 16 (16 - 17)            |          |
|                             | Missing                               | 102   | 18  | 18 (11 - 26)            |          |

\*Calculated using the chi-square test

**Table 2f** Prevalence of SARS-CoV-2 seropositivity by COVID-19 related characteristics, both hospitals, PRECISE 2, April 2021

| COVID-19 related characteristics                      |  | Total | SARS-CoV-2 seropositive |                  |          |
|---|--|-------|-------------------------|------------------|----------|
|   |  | N     | n                       | % (95% CI)       | p-value* |
| <b>Daily contact with COVID-19 patients</b>           | Contact with COVID-19 patients         | 1136  | 265                     | 23 (21 - 26)     | <0.001   |
|   | Contact with patients without COVID-19 | 2,500 | 463                     | 19 (17 - 20)     |          |
|   | No patient contact                     | 1,449 | 170                     | 12 (10 - 14)     |          |
| <b>Previous COVID-19 symptoms</b>                     | No symptoms                            | 2913  | 169                     | 5.8 (5.0 - 6.7)  | <0.001   |
|   | Had symptoms                           | 2171  | 729                     | 34 (32 - 36)     |          |
|   | Missing                                | 1     | 0                       | -                |          |
| <b>Severity of symptoms</b>                           | No symptoms                            | 2913  | 169                     | 5.8 (5.0 - 6.7)  | <0.001   |
|   | Mild symptoms                          | 1502  | 335                     | 22 (20 - 24)     |          |
|   | Significant symptoms                   | 621   | 364                     | 59 (55 - 63)     |          |
|   | Severe (hospitalised)                  | 47    | 30                      | 64 (49 - 77)     |          |
|   | Missing                                | 1     | 0                       | -                |          |
| <b>Previous positive COVID-19 PCR test</b>            | No                                     | 4273  | 235                     | 5.5 (4.8 - 6.2)  | <0.001   |
|   | Yes                                    | 812   | 663                     | 82 (79 - 84)     |          |
| <b>Symptoms at time of previous positive PCR test</b> | No                                     | 172   | 87                      | 51 (43 - 58)     | <0.001   |
|   | Yes                                    | 640   | 576                     | 90.0 (87 - 92.2) |          |
| <b>Severity of symptoms at time of PCR test</b>       | No symptoms                            | 172   | 87                      | 51 (43 - 58)     | <0.001   |
|   | Mild symptoms                          | 256   | 226                     | 88 (84 - 92.0)   |          |
|   | Significant symptoms                   | 351   | 320                     | 91.2 (88 -       |          |
|   | Severe (hospitalised)                  | 32    | 30                      | 93.8 (79 -       |          |
|   | Missing                                | 1     | 0                       | -                |          |

\*Calculated using the chi-square test

**Table 2g** Prevalence of SARS-CoV-2 seropositivity for general support staff, by role and hospital, PRECISE 2, April 2021

| Role               | St James's Hospital |              |            | University Hospital Galway |              |            | Both hospitals |              |            |
|--------------------|---------------------|--------------|------------|----------------------------|--------------|------------|----------------|--------------|------------|
|                    | Total               | Seropositive |            | Total                      | Seropositive |            | Total          | Seropositive |            |
|                    | N                   | n            | %          | N                          | n            | %          | N              | n            | %          |
| Domestic/ Cleaning | 62                  | 15           | 24%        | 45                         | 9            | 20%        | 107            | 24           | 22%        |
| Catering           | 83                  | 23           | 28%        | 18                         | 5            | 28%        | 101            | 28           | 28%        |
| Maintenance        | 27                  | 6            | 22%        | 24                         | 1            | 4.2%       | 51             | 7            | 14%        |
| Security           | 33                  | 6            | 18%        | 14                         | 3            | 21%        | 47             | 9            | 19%        |
| Porter             | 20                  | 6            | 30%        | 13                         | 1            | 7.7%       | 33             | 7            | 21%        |
| Chaplain           | 11                  | 3            | 27%        | 2                          | 0            | 0.0%       | 13             | 3            | 23%        |
| Other              | 7                   | 1            | 14%        | 0                          | 0            | -          | 7              | 1            | 14%        |
| Driver             | 0                   | 0            | -          | 6                          | 2            | 33%        | 6              | 2            | 33%        |
| <b>Total</b>       | <b>243</b>          | <b>60</b>    | <b>25%</b> | <b>122</b>                 | <b>21</b>    | <b>17%</b> | <b>365</b>     | <b>81</b>    | <b>22%</b> |

**Table 2h** Prevalence of asymptomatic SARS-CoV-2 infection, by hospital location and ethnicity, PRECISE 2, April 2021

|                                   |                                   | Total seropositive | Asymptomatic SARS-CoV-2 infection |                |          |
|-----------------------------------|-----------------------------------|--------------------|-----------------------------------|----------------|----------|
|                                   |                                   | N                  | n                                 | % (95% CI)     | p-value* |
| <b>St James's Hospital</b>        | Total                             | 623                | 121                               | 19 (16 - 23)   | 0.009    |
|                                   | Irish                             | 401                | 82                                | 20 (17 - 25)   |          |
|                                   | Other white background            | 56                 | 13                                | 23 (13 - 36)   |          |
|                                   | Asian                             | 122                | 13                                | 11 (5.8 - 18)  |          |
|                                   | African or other black background | 29                 | 11                                | 38 (21 - 58)   |          |
|                                   | Other                             | 15                 | 2                                 | 13 (1.7 - 40)  |          |
| <b>Galway University Hospital</b> | Total                             | 275                | 48                                | 17 (13 - 22)   | 0.531    |
|                                   | Irish                             | 194                | 35                                | 18 (13 - 24)   |          |
|                                   | Other white background            | 38                 | 5                                 | 13 (4.4 - 28)  |          |
|                                   | Asian                             | 26                 | 5                                 | 19 (6.6 - 39)  |          |
|                                   | African or other black background | 10                 | 3                                 | 30 (6.7 - 65)  |          |
|                                   | Other                             | 7                  | 0                                 | -              |          |
| <b>Both hospitals</b>             | Total                             | 898                | 169                               | 19 (16 - 22)   | 0.010    |
|                                   | Irish                             | 595                | 117                               | 20 (17 - 23)   |          |
|                                   | Other white background            | 94                 | 18                                | 19 (12 - 29)   |          |
|                                   | Asian                             | 148                | 18                                | 12 (7.4 - 19)  |          |
|                                   | African or other black background | 39                 | 14                                | 36 (21 - 53)   |          |
|                                   | Other                             | 22                 | 2                                 | 9.1 (1.1 - 29) |          |

\*Calculated using the Chi-square test

**Table 2i** Undiagnosed SARS-CoV-2 infection, by HCW role and hospital location, PRECISE 2, April 2021

|                              | St James's Hospital |      | University Hospital Galway |      | Both hospitals |      |
|------------------------------|---------------------|------|----------------------------|------|----------------|------|
|                              | n                   | %    | n                          | %    | n              | %    |
| <b>Admin</b>                 | 19                  | 10%  | 5                          | 11%  | 24             | 10%  |
| <b>Medical/dental</b>        | 12                  | 6.3% | 8                          | 18%  | 20             | 8.5% |
| <b>Nursing/ midwifery</b>    | 79                  | 42%  | 19                         | 42%  | 98             | 42%  |
| <b>Allied health</b>         | 32                  | 17%  | 6                          | 13%  | 38             | 16%  |
| <b>General support</b>       | 22                  | 12%  | 4                          | 8.8% | 26             | 11%  |
| <b>Health care assistant</b> | 26                  | 14%  | 2                          | 4.4% | 28             | 12%  |
| <b>Other</b>                 | 0                   | 0.0% | 1                          | 2.2% | 1              | 0.4% |
| <b>Total</b>                 | 190                 | 100% | 45                         | 100% | 235            | 100% |

**Table F.** Characteristics of fully vaccinated participants with PCR confirmed infection i.e. vaccine breakthrough cases, both hospitals (n=23), PRECISE 2, April 2021

|                   | Participant characteristics | PCR positive $\geq 14$ days after second vaccine dose (N=23) |      |
|-------------------|-----------------------------|--|------|
|                   |                             | n  | %    |
| <b>Hospital</b>   | St James's Hospital         | 18   | 78%  |
|                   | University Hospital Galway  | 5  | 22%  |
| <b>Age groups</b> | 18-29                       | 2  | 8.7% |
|                   | 30-39                       | 6  | 26%  |
|                   | 40-49                       | 8  | 35%  |
|                   | 50-59                       | 5  | 22%  |
|                   | $\geq 60$                   | 2  | 8.7% |

|  |  |    |      |
|--|--|----|------|
| <b>Sex</b>                                     | Female                                       | 15 | 65%  |
|  | Male   | 8  | 35%  |
| <b>Ethnicity</b>                               | Irish  | 12 | 52%  |
|  | Any other white background                   | 1  | 4.3% |
|  | Asian background                             | 8  | 35%  |
|  | African or other black background            | 2  | 8.7% |
|  | Other  | 0  | 0.0% |
| <b>Country of birth</b>                        | Ireland                                      | 12 | 52%  |
|  | United Kingdom                               | 0  | 0.0% |
|  | India  | 4  | 17%  |
|  | Philippines                                  | 4  | 17%  |
|  | Poland                                       | 1  | 4.3% |
|  | USA  | 0  | 0.0% |
|  | Other  | 0  | 0.0% |
| <b>Education</b>                               | Primary                                      | 0  | 0.0% |
|  | Secondary                                    | 2  | 8.7% |
|  | Third level                                  | 11 | 48%  |
|  | Post-graduate                                | 10 | 43%  |
| <b>Role</b>                                    | Admin  | 0  | 0.0% |
|  | Medical/dental                               | 0  | 0.0% |
|  | Nursing/ midwifery                           | 10 | 43%  |
|  | Allied health                                | 5  | 22%  |
|  | General support                              | 2  | 8.7% |
|  | Health care assistant                        | 4  | 17%  |
|  | Other  | 2  | 8.7% |
| <b>Workplace exposure to COVID-19 patients</b> | No patient contact                           | 2  | 8.7% |
|  | Daily contact with COVID-19 patients         | 9  | 39%  |
|  | Daily contact with patients without COVID-19 | 12 | 52%  |
| <b>Lives with</b>                              | Alone  | 1  | 4.3% |
|  | With others                                  | 22 | 96%  |
|  | Missing                                      | 0  | 0.0% |
| <b>Lives with HCW</b>                          | Yes  | 13 | 57%  |
|  | No   | 10 | 43%  |

|  |        |    |      |
|--|--------|----|------|
| <b>Vaccine type</b>                              | Pfizer | 23 | 100% |
|  | Other  | 0  | 0.0% |
| <b>Symptoms at the time of positive PCR test</b> | Yes    | 5  | 22%  |
|  | No     | 18 | 78%  |