Short report

Prevalence of SARS-CoV-2 antibodies among workers of the public higher education institutions of Porto, Portugal: a cross-sectional study

Paula Meireles ,[1] Joana Amaro,[1,2] Joana Pinto da Costa,[1] Mariana Mendes Lopes,[1] Tatiana Varandas,[1] Pedro Norton,[1,2,3] João Tiago Guimarães,[1,2,4] Milton Severo,[1] Henrique Barros[1,2]

[1]EPI Unit, Instituto de Saúde Pública da Universidade do Porto, Porto, Portugal
[2]Faculdade de Medicina, Universidade do Porto, Porto, Portugal
[3]Serviço de Saúde Ocupacional, Centro Hospitalar Universitário de São João, Porto, Portugal
[4]Serviço de Patologia Clínica, Centro Hospitalar Universitário de São João, Porto, Portugal

Correspondence to
Dr Paula Meireles, EPIUnit, Instituto de Saúde Pública, Universidade do Porto, Rua das Taipas, nº 135, 4050-600, Porto, Portugal;
paula.meireles@ispup.up.pt

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ABSTRACT

Objectives To assess the prevalence of SARS-CoV-2-specific IgM and IgG antibodies among workers of the three public higher education institutions of Porto, Portugal, up to July 2020.

Methods A rapid point-of-care test for specific IgM and IgG antibodies of SARS-CoV-2 was offered to all workers (SD Biosensor STANDARD Q COVID-19 IgM/IgG Duo and STANDARD Q COVID-19 IgM/IgG Combo). Testing was performed and a questionnaire was completed by 4592 workers on a voluntary basis from 21 May to 31 July 2020. We computed the apparent IgM, IgG, and combined IgM or IgG prevalence, along with the true prevalence and 95% credible intervals (95% CrI) using Bayesian inference.

Results We found an apparent prevalence of 3.1% for IgM, 1.0% for IgG and 3.9% for either. The estimated true prevalence was 2.0% (95% CrI 0.1% to 4.3%) for IgM, 0.6% (95% CrI 0.0% to 1.3%) for IgG, and 2.5% (95% CrI 0.1% to 5.3%) for IgM or IgG. A SARS-CoV-2 molecular diagnosis was reported by 21 (0.5%) workers; and of these, 90.5% had a reactive IgG result. Seroprevalence was higher among those reporting contacts with confirmed cases, having been quarantined, having a previous molecular negative test or having had symptoms.

Conclusions The seroprevalence among workers from the three public higher education institutions of Porto after the first wave of the SARS-CoV-2 infection was similar to national estimates for the same age working population. However, the estimated true seroprevalence was approximately five times higher than the reported SARS-CoV-2 infection based on a molecular test.

Key messages

What is already known about this subject?
- Seroprevalence studies are essential to know the real extension of SARS-CoV-2 infection, population immunity and workplace risk.
- Among the working population, studies are mostly concerned with healthcare workers.

What are the new findings?
- The true prevalence of SARS-CoV-2-specific antibodies among workers of the higher education institutions of Porto, Portugal by the end of the first SARS-CoV-2 wave was 2.5% (95% CrI 0.1% to 5.3%), five times greater than the self-reported period prevalence of SARS-CoV-2 infection as diagnosed by a molecular test (0.5%).

How might this impact on policy or clinical practice in the foreseeable future?
- These results provide a baseline extension of the SARS-CoV-2 infection in a working population that encompasses a wide range of socioeconomic positions and different levels of risk exposure.

INTRODUCTION

The SARS-CoV-2 infection can cause very severe disease, particularly among individuals with underlying conditions. Commonly it progresses unnoticed with few or no symptoms[1]—additional limited testing capacity has led to a variable undiagnosed rate.

Seroprevalence studies are based on the identification of SARS-CoV-2-specific antibodies. In this case of an emergent agent, the entire population is initially susceptible. Therefore, the presence of specific antibodies provides estimates of the cumulative incidence of infection. In SARS-CoV-2 infection, almost all of the infected individuals seroconvert within 2–3 weeks.[2–4]

Diseases with an impact on the working population cause very high individual and societal costs. Activities where interpersonal contact is inevitable, structural or individual lack of compliance with preventive measures, sharing the same office or canteen space, and meeting in overcrowded rooms may increase the SARS-CoV-2 infection in the workplace.[5] Preventive measures include the use of face masks, hand sanitisers, increased distance between workers, scattered working hours or working from home. The latter has been deemed mandatory in Portugal from 18 March to 30 June 2020. The return to workplace activities provided an excellent opportunity to obtain data on serum status. Only a few studies have been conducted among higher education workers.[6–8] Therefore, we aimed to assess the prevalence of SARS-CoV-2-specific IgM and IgG antibodies among workers

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of public higher education institutions of Porto, Portugal from May to July 2020.

METHODS

All workers of the three public higher education institutions of Porto city were offered a serological point-of-care test for SARS-CoV-2-specific IgM and IgG antibodies from 21 May to 31 July 2020. Participation was voluntary, and scheduling was initiated by the workers. At the day of testing, workers were invited to answer to two questionnaires—one to evaluate clinical aspects, conducted by the trained researcher who performed the test, and another self-administered to address sociodemographic characteristics.

The clinical questionnaire included information on comorbidities, contacts with confirmed SARS-CoV-2 cases in the previous 2 weeks, symptoms since the beginning of 2020 (categorised into asymptomatic; moderately symptomatic (one or two of the following symptoms: cough, dyspnoea, odynophagia, headache, vomiting or nausea, diarrhoea, asthenia or fever); and symptomatic (at least three of the listed symptoms, or dysgeusia or anosmia)), and previous SARS-CoV-2 diagnostic tests. The self-administered questionnaire inquired about gender identity, nationality, educational level, occupation, currently working from home, self-perception of having been infected, travelling abroad since December 2019, contacts with confirmed SARS-CoV-2 cases and having been quarantined since January 2020.

Participants provided written informed consent to all procedures.

SARS-CoV-2-specific IgM and IgG antibodies determination and follow-up

Two point-of-care tests were used—the Standard Q COVID-19 IgM/IgG Duo (SD Biosensor) used from 21 May to 10 July, n=3987 (manufacturer reported sensitivity of 92.6% 8 days after symptom onset and specificity of 96.5% for both IgG and IgM); and the Standard Q COVID-19 IgM/IgG Combo (SD Biosensor) from 10 July to 31 July, n=605 (manufacturer reported sensitivity of 94.5% 7 or more days after symptom onset and specificity of 95.7% for both IgG and IgM). Lower sensitivity was found in independent studies.[9]

Participants reporting current symptoms or high-risk contact in the previous 14 days (spending more than 15 min within 2 metres of a confirmed case without any personal protective equipment), and those with a reactive result only for IgM were offered a referral to a reverse transcriptase-polymerase chain reaction (RT-PCR) test, scheduled within 1 working day.

Statistical analysis

The apparent seroprevalence was computed as the proportion of individuals with a reactive result in the IgM or IgG band. We compared groups using the Pearson X^2 or the Fisher's exact test, when the assumptions for the X^2 test did not hold. To measure the association of participants' characteristics and IgM, IgG, and IgM or IgG seroprevalence, we computed the odds ratios (OR) and 95% CI adjusted for age, gender, educational level and nationality (except the occupational group that was not adjusted for education) using a logistic regression in SPSS V.27.

We estimated the true prevalence and 95% credible intervals (95% CrI) using Bayesian inference, considering a uniform prior distribution for sensitivity ranging from 0.65 to 0.97, and specificity between 0.83 and 1, as described by Speybroeck *et al*.[10] Estimates were obtained using the 'prevalence' and 'rjags' package in R.[11]

RESULTS

We tested 4592 workers: 148 from the Nursing School of Porto, 816 from the Polytechnic of Porto and 3628 from the University of Porto, approximately 99%, 40% and 75% of the total workers, respectively. Participants' characteristics and antibodies' apparent seroprevalence according to the characteristics of the workers are presented in table 1. One hundred forty-two (3.1%) were reactive for IgM, 45 (1.0%) for IgG and 179 (3.9%) for at least one. The estimated true prevalence was 2.0% (95% CrI 0.1% to 4.3%) for IgM, 0.6% (95% CrI 0.0% to 1.3%) for IgG, and 2.5% (95% CrI 0.1% to 5.3%) for IgM or IgG.

IgM seroprevalence increased significantly with age, and it was higher among those with the lowest educational levels. No gender or nationality differences were found, as well as in working from home status. IgM prevalence was higher among those with a previous diagnosis of SARS-CoV-2 infection (23.8%) when compared with those never tested (3.0%) or those who tested negative (2.8%). IgM was also higher among those with previous contact with confirmed cases (adjusted OR (aOR) 2.22, 95% CI 1.22 to 4.04) and in those quarantined (aOR 2.94, 95% CI 1.53 to 5.63). Travelling abroad, symptoms perceived as unusual or sudden, and self-perception of having been infected were not associated with IgM presence.

IgG seroprevalence did not differ according to age, gender, educational level, occupational group or working from home. Non-Portuguese workers had a higher IgG seroprevalence (aOR 2.98, 95% CI 1.13 to 7.88). Almost all of those diagnosed with SARS-CoV-2 infection had a reactive IgG test (19 of 21; 90.5%), and IgG prevalence was also higher among those who tested negative than those never tested (aOR 7.04, 95% CI 2.75 to 18.06). IgG seroprevalence was higher among those with known contact with a confirmed case (aOR 14.26, 95% CI 7.28 to 27.91), and among those who had been quarantined (aOR 42.79, 95% CI 22.18 to 82.54). Participants classified as symptomatic had higher IgG seroprevalence, particularly those with unusual or sudden onset of symptoms (4.2% vs 0.4% among moderately symptomatic vs 0.6% among asymptomatic). IgG reactivity was more common in participants perceived the probability of having already been infected as high or very high compared with those perceiving it as low or very low (aOR 11.43, 95% CI 4.16 to 31.45).

A referral to an RT-PCR test was offered to 145 participants. Four refused (all IgM reactive). Of the remaining, 130 were IgM-only reactive (15 also presented symptoms), 3 were IgM and IgG reactive, 7 presented symptoms (IgM and IgG non-reactive) and 1 had high-risk contacts (IgM and IgG non-reactive). Of the 141 RT-PCR tests, one was positive and corresponded to a worker referred due to symptoms and non-reactive results for IgM and IgG.

DISCUSSION

We found a 3.9% seroprevalence of IgM and/or IgG among workers of the three public higher education institutions of Porto, and a true prevalence of 2.5% (95% CrI 0.1% to 5.3%). The apparent prevalence was higher than the point estimate of 2.9% seroprevalence of IgM and/or IgG found in the Portuguese serological survey (ISNCOVID-19) conducted approximately in the same time frame. It was similar to the prevalence found among those employed (3.8%; 95% CI 2.2% to 6.3%).[12] Also, among the University of Lisbon workers tested approximately at

Table 1 Characteristics of participants, IgM, IgG, and IgM or IgG apparent seroprevalence according to those characteristics among workers from the public higher education institutions of Porto, Portugal, assessed from May to July 2020

	Total number of participants	IgM seroprevalence		IgG seroprevalence		IgM or IgG	
	N	%	aOR† (95% CI)	%	aOR† (95% CI)	%	aOR† (95% CI)
Overall	4592	142 (3.1)		45 (1.0)		179 (3.9)	
Institution							
Nursing School of Porto	148	0.7	0.19 (0.03 to 1.39)	2.0	2.50 (0.74 to 8.43)	2.7	0.65 (0.24 to 1.80)
Polytechnic of Porto	816	2.5	0.74 (0.45 to 1.20)	0.6	0.65 (0.25 to 1.67)	2.9	0.71 (0.46 to 1.12)
University of Porto	3628	3.3	Reference	1.0	Reference	4.2	Reference
P value		0.094		0.239		0.198	
Sociodemographic characteristics							
Age strata (years)							
<30	435	1.1	Reference	0.9	Reference	2.1	Reference
30–39	1097	1.9	1.56 (0.57 to 4.23)	0.7	0.58 (0.17 to 2.04)	2.6	1.16 (0.54 to 2.52)
40–49	1479	3.0	2.74 (1.06 to 7.09)	0.9	0.74 (0.22 to 2.47)	3.7	1.80 (0.86 to 3.74)
50–59	936	4.3	3.66 (1.38 to 9.71)	1.3	1.03 (0.29 to 3.61)	5.2	2.41 (1.12 to 5.15)
60–69	505	5.1	4.18 (1.51 to 11.57)	1.4	1.06 (0.27 to 4.17)	6.3	2.77 (1.24 to 6.19)
≥70	38	7.9	8.31 (1.83 to 37.73)	2.6	1.67 (0.17 to 16.76)	7.9	4.06 (1.01 to 16.25)
Missing	102						
P value		<0.001		0.610		<0.001	
Gender							
Men	1643	2.9	Reference	1.3	Reference	4.0	Reference
Women	2917	3.2	1.21 (0.84 to 1.74)	0.8	0.62 (0.34 to 1.13)	3.8	1.03 (0.74 to 1.41)
Other	7						
Missing	25						
P value		0.681		0.099		0.828	
Educational level							
Basic education	203	6.9	2.06 (1.10 to 3.83)	1.5	1.21 (0.35 to 4.19)	8.4	2.00 (1.14 to 3.52)
Secondary or post-secondary education	440	4.1	1.32 (0.76 to 2.28)	0.7	0.56 (0.17 to 1.89)	4.8	1.20 (0.73 to 1.98)
Bachelor's or Master's	2056	2.4	0.99 (0.66 to 1.48)	0.7	0.55 (0.27 to 1.15)	3.1	0.91 (0.63 to 1.31)
Doctorate	1852	3.2	Reference	1.3	Reference	4.2	Reference
Missing	41						
P value		0.003		0.146		0.001	
Nationality							
Portuguese	4327	3.1	Reference	0.9	Reference	3.8	Reference
Non-Portuguese	198	3.5	1.68 (0.76 to 3.71)	2.5	2.98 (1.13 to 7.88)	5.6	1.99 (1.04 to 3.79)
Missing	67						
P value		0.860		0.045*		0.293	
Occupational group‡							
High-skilled white collar	3954	3.0	Reference	1.0	Reference	3.8	Reference
Low-skilled white collar	538	3.5	1.05 (0.63 to 1.74)	0.7	0.78 (0.27 to 2.23)	4.3	1.04 (0.66 to 1.65)

continued

Table 1 continued

	Total number of participants	IgM seroprevalence		IgG seroprevalence		IgM or IgG	
	N	%	aOR† (95% CI)	%	aOR† (95% CI)	%	aOR† (95% CI)
High/low-skilled blue collar	36	8.3	2.82 (0.84 to 9.49)	0.0	–	8.3	2.14 (0.64 to 7.16)
Missing	64						
P value		0.142		0.678		0.331	
Currently working from home							
No	1260	3.5	Reference	1.1	Reference	4.6	Reference
Yes, partially	1326	3.1	0.90 (0.55 to 1.46)	0.8	0.56 (0.24 to 1.34)	3.6	0.75 (0.49 to 1.17)
Yes, in full	1915	2.9	0.90 (0.58 to 1.40)	1.0	0.72 (0.34 to 1.55)	3.7	0.82 (0.55 to 1.21)
Other (sick leave, paternity/maternity leave/ sabbatical leave)	23	0.0	–	4.3	3.28 (0.39 to 27.73)	4.3	0.74 (0.10 to 5.70)
Missing	68						
P value		0.634		0.367		0.522	
Infection-related characteristics							
Contact with confirmed cases since January 2020							
No	4100	3.0	Reference	0.6	Reference	3.6	Reference
Yes	226	6.2	2.22 (1.22 to 4.04)	7.1	14.26 (7.28 to 27.91)	11.1	3.69 (2.32 to 5.88)
Missing	118						
P value		0.014		<0.001		<0.001	
Quarantine since January 2020							
No	4384	2.9	Reference	0.5	Reference	3.4	Reference
Yes	142	8.5	2.94 (1.53 to 5.63)	15.5	42.79 (22.18 to 82.54)	19.7	7.31 (4.60 to 11.63)
Missing	66						
P value		0.001*		<0.001*		<0.001	
Travel abroad since December 2019							
No	3124	3.2	Reference	0.9	Reference	4.0	Reference
Yes	1210	3.0	0.97 (0.63 to 1.48)	1.2	1.02 (0.51 to 2.07)	3.9	0.98 (0.67 to 1.43)
Missing	110						
P value		0.735		0.540		0.792	
Symptoms since January 2020							
Asymptomatic	1421	3.4	Reference	0.5	Reference	3.8	Reference
Moderately symptomatic§	1936	3.0	0.93 (0.63 to 1.38)	0.6	1.34 (0.51 to 3.50)	3.6	1.00 (0.69 to 1.46)
Symptomatic¶	1006	3.1	0.99 (0.62 to 1.60)	2.4	6.09 (2.55 to 14.50)	5.0	1.52 (1.01 to 2.28)
Missing	229						
P value		0.789		<0.001		0.166	
Symptoms unusual or sudden since January 2020							
Asymptomatic	2902	3.3	Reference	0.6	Reference	3.8	Reference
Moderately symptomatic§	965	2.9	1.01 (0.66 to 1.52)	0.4	0.79 (0.26 to 2.36)	3.2	0.96 (0.63 to 1.44)
Symptomatic¶	496	3.2	1.02 (0.58 to 1.78)	4.2	8.04 (4.14 to 15.61)	6.5	1.87 (1.23 to 2.84)
Missing	229						

continued

Table 1 continued

	Total number of participants	IgM seroprevalence		IgG seroprevalence		IgM or IgG	
	N	%	aOR† (95% CI)	%	aOR† (95% CI)	%	aOR† (95% CI)
P value		0.849		<0.001		0.008	
Self-perception of the probability of having already been infected (excluding those with diagnosis)							
Very low or low	3416	3.0	Reference	0.4	Reference	3.4	Reference
Moderate	724	2.8	0.94 (0.57 to 1.54)	0.7	1.88 (0.66 to 5.37)	3.3	1.07 (0.64 to 1.59)
High or very high	142	4.9	1.47 (0.63 to 3.44)	4.2	11.43 (4.16 to 31.45)	8.5	2.47 (1.29 to 4.73)
Missing	142						
P value		0.388		<0.001*		0.006	

*P value for the Fisher's exact test.
†ORs adjusted for age, gender, educational level and nationality.
‡Not adjusted for the educational level.
§Moderately symptomatic: having or having had one or two of the following symptoms: cough, dyspnoea, odynophagia, headache, vomiting or nausea, diarrhoea, fever, arthralgias, myalgia, asthenia.
¶Symptomatic defined as having or having had at least three symptoms listed before, or dysgeusia or anosmia.
aOR, adjusted OR.

the same time, the seroprevalence for IgG was of 1.5%,[6] higher than the 1.0% we found. However, as sampling methods and tests used were different, comparisons and inferences must be cautious.

As expected, those reporting known indicators of a higher probability of being infected—known contacts with confirmed cases, ever quarantined, who had symptoms—had higher seroprevalence overall. Those with a previous negative molecular test had a higher seroprevalence than those never tested, which shows that false-negative results in the molecular tests likely occurred. Also, interesting was the fact that seroprevalence was higher among those perceiving their probability of having been infected as high or very high, showing an appropriate self-assessment of risk.

One important finding is that the seroprevalence was approximately eight times greater than reported SARS-CoV-2 infection by a molecular test, or five times greater if we consider the true prevalence estimate. Even considering that we may be overestimating the seroprevalence,[13] it is reasonable to expect that the SARS-CoV-2 infection was considerably more frequent than based on notified cases as shown previously,[14] particularly because testing was restricted during the initial phase of the epidemic.

No workers with an isolated IgM reactive result had a positive RT-PCR, supporting the evidence that when antibodies start being detectable the virus detection by RT-PCR is lower, and that antibody tests are appropriate to identify those previously infected but not to detect active infections.[2] Nevertheless, we cannot rule out the hypothesis of false-positive IgM results due to lower specificity.[15] Importantly, the test results were read by the trained field researchers who performed it and in case of doubt there was always an experienced field supervisor to be consulted.

As we had to use two different tests, though from the same manufacturer and with similar performance characteristics, error in the prevalence estimate could have occurred. The lower sensitivity of rapid diagnostic tests and in low titre samples[16] and the measurement of the IgM and IgG only could also have led to the underestimation of prevalence. Selection bias limited our ability to infer to the source population, and memory bias may have led to under-reporting of exposures particularly regarding symptoms. These limitations do not seem to change the meaning of our main findings of a low seroprevalence of SARS-CoV-2 at the time of resuming working activities after the first wave of the SARS-CoV-2 infection; and that the estimated true seroprevalence was approximately five times greater than the reported SARS-CoV-2 infection burden using molecular test information.

Twitter Paula Meireles @PaulaMeireles5

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ORCID iD

Paula Meireles http://orcid.org/0000-0001-9055-7491

REFERENCES

1 Cevik M, Kuppalli K, Kindrachuk J, *et al*. Virology, transmission, and pathogenesis of SARS-CoV-2. *BMJ* 2020;371:m3862.
2 Sethuraman N, Jeremiah SS, Ryo A. Interpreting diagnostic tests for SARS-CoV-2. *JAMA* 2020;323:2249–51.
3 Stephens DS, McElrath MJ. COVID-19 and the path to immunity. *JAMA* 2020;324:1279–81.
4 Dan JM, Mateus J, Kato Y, *et al*. Immunological memory to SARS-CoV-2 assessed for up to 8 months after infection. *Science* 2021;371:eabf4063.
5 European centre for disease prevention and control (ECDC). COVID-19 clusters and outbreaks in occupational settings in the EU/EEA and the UK. *Stockholm* 2020 https://www.ecdc.europa.eu/sites/default/files/documents/COVID-19-in-occupational-settings.pdf
6 Figueiredo-Campos P, Blankenhaus B, Mota C, *et al*. Seroprevalence of anti-SARS-CoV-2 antibodies in COVID-19 patients and healthy volunteers up to 6 months post disease onset. *Eur J Immunol* 2020;50:2025–40.
7 Tsitsilonis OE, Paraskevis D, Lianidou E, *et al*. Seroprevalence of antibodies against SARS-CoV-2 among the personnel and students of the National and Kapodistrian University of Athens, Greece: a preliminary report. *Life* 2020;10. doi:10.3390/life10090214. [Epub ahead of print: 21 09 2020].
8 Milani GP, Rota F, Favero C, *et al*. Detection of IgM, IgG and SARS-CoV-2 RNA among the personnel of the University of Milan, March through may 2020: the unicorn study. *BMJ Open* 2021;11:e046800.
9 Find. SARS-COV-2 test performance. Available: https://www.finddx.org/covid-19/ab-test-perf/ [Accessed 31 May 2021].
10 Speybroeck N, Devleesschauwer B, Joseph L, *et al*. Misclassification errors in prevalence estimation: Bayesian handling with care. *Int J Public Health* 2013;58:791–5.
11 Devleesschauwer B, Torgerson P, Charlier J. *Prevalence: tools for prevalence assessment studies. R package version 0.4.0*, 2014. http://cran.r-project.org/package=prevalence
12 Kislaya I, Gonçalves P, Barreto M. Seroprevalence of SARS-CoV-2 infection in Portugal in May-July 2020: results of the first national serological survey (ISNCOVID-19). *Acta Médica Portuguesa* 2021;34.
13 Kumleben N, Bhopal R, Czypionka T, *et al*. Test, test, test for COVID-19 antibodies: the importance of sensitivity, specificity and predictive powers. *Public Health* 2020;185:88–90.
14 Havers FP, Reed C, Lim T, *et al*. Seroprevalence of antibodies to SARS-CoV-2 in 10 sites in the United States, March 23-May 12, 2020. *JAMA Intern Med* 2020;180:1576–86.
15 Conklin SE, Martin K, Manabe YC, *et al*. Evaluation of serological SARS-CoV-2 lateral flow assays for rapid point-of-care testing. *J Clin Microbiol* 2021;59:e02020–20.
16 Lagerqvist N, Maleki KT, Verner-Carlsson J, *et al*. Evaluation of 11 SARS-CoV-2 antibody tests by using samples from patients with defined IgG antibody titers. *Sci Rep* 2021;11:7614.