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A systematic review of seroprevalence of SARS-CoV-2 antibodies prior to the widespread introduction of vaccine programmes in the WHO European Region, January - December 2020

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A systematic review of seroprevalence of SARS-CoV-2 antibodies prior to the widespread introduction of vaccine programmes in the WHO European Region, January - December 2020

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ABSTRACT

Objectives

To undertake a systematic literature review of SARS-CoV-2 population seroprevalence studies undertaken in the WHO European Region to measure pre-existing and cumulative seropositivity prior to the roll out of vaccination programmes.

Method

We systematically searched MEDLINE, ELSEVIER and the pre-print servers medRxiv and bioRxiv within the “COVID-19 Global literature on coronavirus disease” database using a predefined search strategy. Studies published before the widespread implementation of COVID-19 vaccination programmes in January 2021 among the general population and blood donors, at national and regional levels. Study risk of bias was assessed using a quality scoring system based on sample size, sampling and testing methodologies. Articles were supplemented with unpublished WHO-supported Unity-aligned seroprevalence studies and other studies reported directly to WHO Regional Office for Europe and ECDC.

Results

In total, 111 studies from 26 countries published or conducted between 01/01/2020 and 31/12/2020 across the WHO European Region were included. A significant heterogeneity in implementation was noted across the studies, with a paucity of studies from the east of the Region. Sixty-four (58%) studies were assessed

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3 to be of medium to high risk of bias. Overall, SARS-CoV-2 seropositivity prior to widespread community
4 circulation was very low. National seroprevalence estimates after circulation started ranged from 0% to
5 51.3% (median 2.2% (IQR 0.7-5.2%); n=124), while sub-national estimates ranged from 0% to 52%
6 (median 5.8% (IQR 2.3-12%); n=101), with the highest estimates in areas following widespread local
7 transmission.
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13 **Conclusion**

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15 The review found evidence of low national SARS-CoV-2 seroprevalence (<10%) across the WHO
16 European Region by the end of 2020. The low levels of SARS-CoV-2 antibody in most populations prior
17 to the start of vaccine programmes underlines the critical importance of targeted vaccination of priority
18 groups at risk of severe disease, while maintaining reduced levels of transmission to minimize population
19 morbidity and mortality.
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28 **INTRODUCTION**

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30 The novel virus, Severe Acute Respiratory Syndrome–Coronavirus–2 (SARS-CoV-2) was first identified
31 in Wuhan, China in December 2019 and spread rapidly around the world. At that time, the transmissibility,
32 population susceptibility, clinical spectrum and infection-severity were all unknown. As of 7 March 2022,
33 approximately 444 million confirmed cases and 6 million deaths have been reported globally, while in the
34 WHO European Region, there have been 182 million cases and 1.9 million deaths (1, 2). However, notified
35 cases and deaths are an underestimate of the true number of infections for reasons including clinical
36 presentation with a large proportion of asymptomatic or mildly symptomatic cases, testing and reporting
37 strategies and health care seeking behaviour (3). Asymptomatic infection has been reported in many studies
38 with the proportion ranging from 6 to 41% (4-6), so a significant proportion of SARS-CoV-2 infections
39 will be missed through case-based surveillance systems (7).
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53 As the majority of infected individuals have a detectable humoral immune response on average 10-14 days
54 after symptom onset and most individuals seroconvert within 3-4 weeks of infection (8), seroprevalence
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3 studies which measure SARS-CoV-2 antibodies can provide an important complement to routine
4 surveillance, particularly as part of the assessment of novel emerging respiratory pathogens. Seroprevalence
5 surveys are essential to assess the age-specific prevalence of pre-existing cross-reactive antibodies in the
6 population; to measure population age-specific cumulative seroincidence as the novel virus spreads and to
7 contribute to estimating infection-severity.
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15 Since the start of the COVID-19 pandemic, there has been a rapid accumulation of seroepidemiological
16 studies describing the seroprevalence of SARS-CoV-2. This review aims to provide a comprehensive
17 review of studies conducted in the WHO European Region between 1 January and 31 December 2020 in
18 the general population, with the aim to synthesize evidence on the extent of transmission across the region
19 and population immunity to this newly emerging infection before the start of the COVID-19 vaccination
20 programmes. As SARS-CoV-2 continues to circulate widely, understanding the age-specific population
21 seropositivity remains critical for policymakers and public health officials to make informed decisions on
22 optimal public health interventions (9).
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32 33 **METHODS**

34 **Search strategy**

35 We searched MEDLINE, WHO COVID, ELSEVIER and the pre-print servers medRxiv and bioRxiv within
36 the WHO “COVID-19 Global literature on coronavirus disease” database on 21/10/2020 and 12/01/2021.
37 The searches spanned the period 1 January - 31 December 2020 and was not restricted by language. We
38 supplemented these articles with WHO-supported Unity seroprevalence studies and unpublished studies
39 reported to WHO Regional Office for Europe and ECDC. The selection process followed the Preferred
40 Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines (10). The full search
41 strategy, search terms as well as inclusion and exclusion criteria are described in Supplementary Material
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Data extraction

We combined the references from all databases, removed duplicates and imported the remaining articles into Rayyan software (11) for screening of titles and abstracts according to the inclusion and exclusion criteria (Supplementary Table S1). After the initial screening of title and abstracts, two independent researchers assessed full-text publications for eligibility. Data from pre-print articles were extracted and later replaced with data from published articles, where necessary. At least two independent researchers extracted the eligible studies; a third researcher resolved any disagreements on assessment of eligibility or extraction. We extracted the following data: first author, publication date, country, region, period of study, population type, population age, sampling method, sample size, laboratory methods used, confirmatory testing, test performance, crude and adjusted point seroprevalence estimates, antibody type and analysis methodology. Comparison was made with weekly laboratory confirmed case and death reports.

Study quality assessment

We developed a quality assessment scoring system to assess the overall risk of bias of each study. The criteria included: a) the sampling frame (to assess representativeness of the general population); b) stratification (age, sex or population); c) recruitment method (random, convenience), d): adequacy of sample size, e): serological methods and validation; f) and statistical analyses (adjustment of results to account for the sensitivity and specificity of the test). A cumulative quality score classified the overall risk of bias of each study into high risk of bias (1-3), medium risk of bias (4-6) or low risk of bias (>6). See Supplementary Table S2 for more details on the quality criteria. For the purposes of quality assessment, the threshold for acceptable test performance was $\geq 95\%$ sensitivity and $>97\%$ specificity for laboratory assays and $\geq 90\%$ sensitivity and $>97\%$ specificity for point-of-care tests (12).

Data analysis

We used descriptive statistics to summarize results. We generated forest plots to display the data and explore variations according to specific characteristics, including time and population group. Correlation between cumulative incidence and cumulative deaths and seroprevalence estimates from studies of the

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3 general population was explored using Spearman's rank correlation. We compared seroprevalence
4 estimates from studies of the general population and the cumulative incidence and deaths at the start of each
5 study. Analyses were performed in Microsoft Excel (version 2016) and R version 4.0.4.
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9 10 **Patient and public involvement**

11 No patient involved
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16 **RESULTS**

17 The literature search resulted in 4,063 studies. After deduplication, application of inclusion and exclusion
18 criteria and supplementation with articles from other sources, a total of 111 studies were included in this
19 review. Of these, 77 were published articles, 19 were preprints, nine were institutional reports, and six were
20 studies were identified through reporting of unpublished results to WHO or ECDC. See Figure 1 PRISMA
21 flow diagram study selection.
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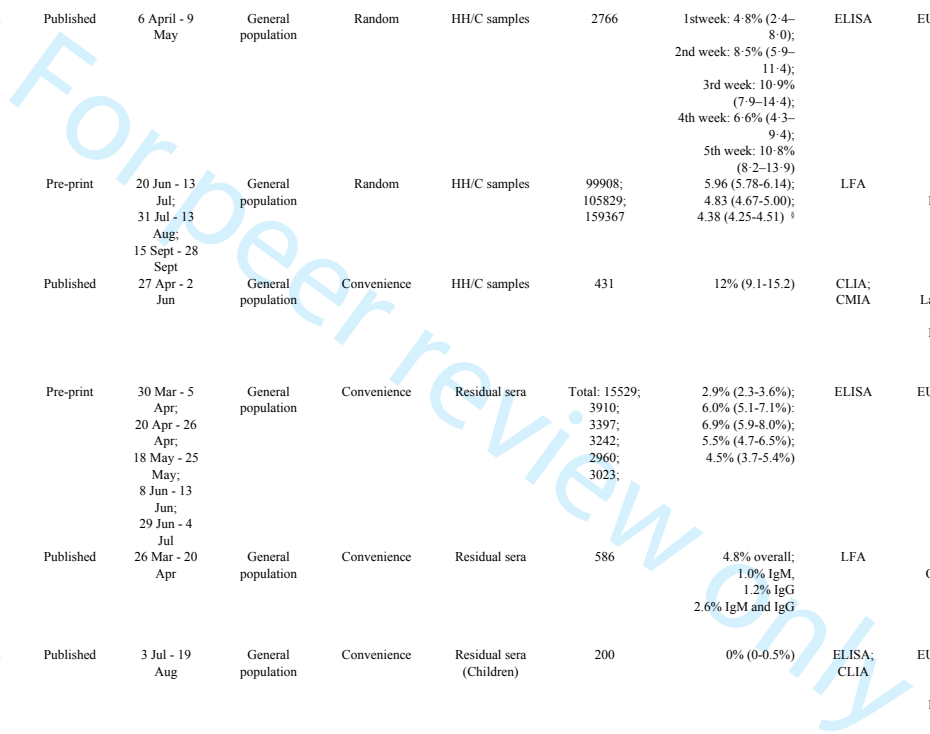
30 The 111 studies included 224 seroprevalence estimates from 26 of the 53 countries in the WHO European
31 Region (Figure 2). The majority of studies (n=82; 74%) were conducted in 19 EU/EEA countries, while 29
32 studies (26%) conducted in seven non-EU/EEA countries (Bosnia and Herzegovina, Georgia, Kyrgyzstan,
33 Republic of Moldova, Russian Federation, Switzerland and the United Kingdom) (Figure 2; Table 1). Fifty-
34 six (50%) studies were aligned with the World Health Organization Unity population-based sero-
35 epidemiological investigation criteria related to study design, data collection and analysis (2). The majority
36 of studies (n=69, 62%) used non-random or convenience sampling of the population. Forty-one (37%)
37 studies used random sampling, while one study did not report sampling methodology. Characteristics and
38 details of included studies are shown in Table 1 and Table 2, respectively.
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Table 2 Characteristics of eligible seroprevalence studies

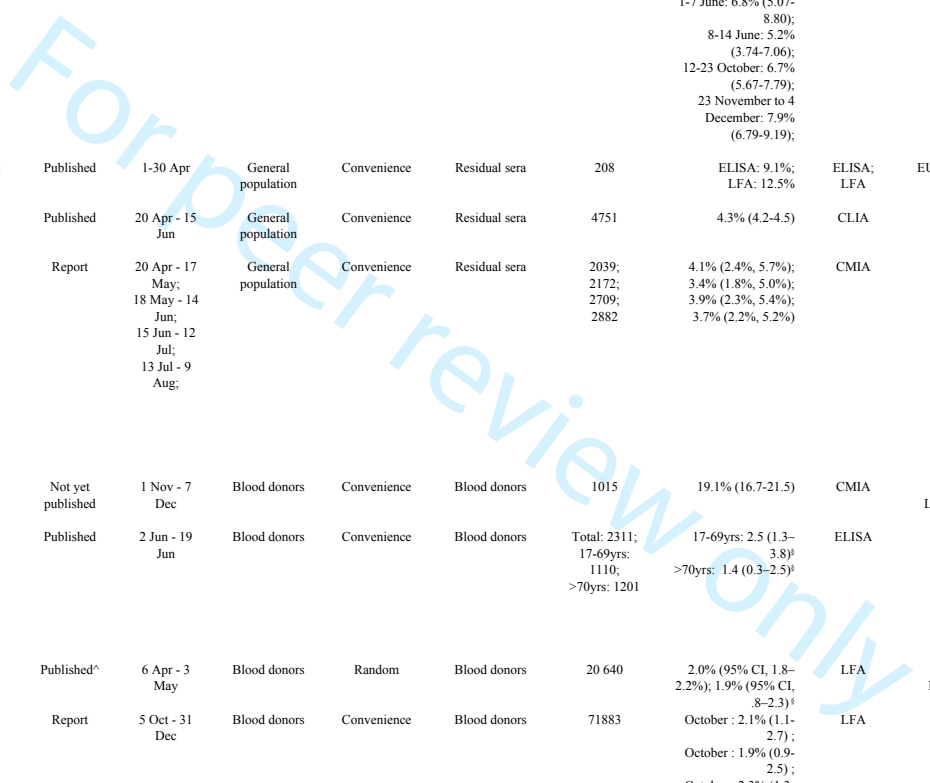
	Author	Country	Study Location	EU/non-EU	WHO UNITY aligned	Geographic location	Publication type	Study period	Study population	Sample method	Sampling frame	No of participants	Seropositivity (%)	Serological method	Assay	Antibody measured/Antigen	Sensitivity (%)	Specificity (%)	Quality score	Overall risk of bias	
1	Household and community																				
2																					
3	1	Knabl (50)	Austria	Tyrol, Ischgl	EU/EEA	Yes	City/local	Published [^]	21-27 Apr	General population	Random	HH/C samples	1473	42.4% (39.8 - 44.7%)	ELISA; CLIA	EUROIMMUN; Abbott Laboratories;	Anti-S IgA; IgG; Anti-N IgG	Not reported	Not reported	8	Low
4	2	Wagner (88)	Austria	Vienna	EU/EEA	No	City/local	Pre-print	12-17 Apr	General population	Convenience	HH/C samples	1655	10.15%	ELISA; ELISA; ELISA; CLIA; MN	EUROIMMUN; Beijing Wantai Biological Pharmacy Enterprise; EUROIMMUN; Roche Diagnostics; In-house;	IgA; IgG IgM and total Abs; IgG; Total Abs; NT-Abs	Not reported	Not reported	3	High
5	3	Ladage (89)	Austria	Weißkirchen/Wachau	EU/EEA	No	City/local	Published	1-15 Jun	General population	Convenience	HH/C samples	835	ELISA: IgG 8.5%; IgA 9.0%;	ELISA;	EUROIMMUN	IgA; IgG	Not reported	Not reported	5	Medium
6	4	Boey (90)	Belgium	Pelt; Alken	EU/EEA	No	Regional	Published [^]	21 Sept - 6 Oct	General population	Random	HH/C samples	362	4.4% (low exposed - Pelt); 14.4% (high exposed - Alken)	ELISA;	Beijing Wantai Biological Pharmacy Enterprise; EUROIMMUN	Total Abs;	99.6%	Not reported	4	Medium
7	5	Bokanjic (91)	Bosnia and Herzegovina	Republika Srpska	non-EU/EEA	Yes	Regional	Not yet published	4 Nov - 16 Dec	General population	Random	HH/C samples	1855	40.4%	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	Total Abs;	94%	100%	N/A	N/A
8	6	Kunchev and Stoitsova (92)	Bulgaria	Plovdiv	EU/EEA	Yes	City/local	Not yet published	18-May-13 Jun	General population	Random	HH/C samples	553	1.08% (0.5-2.35); 0.04% (0-0.12) [§]	ELISA;	EUROIMMUN;	IgG; IgA	Not reported	Not reported	N/A	N/A
9	7	Statens Serum Institut (93)	Denmark	Copenhagen; Aarhus; Aalborg; Næstved; Odense	EU/EEA	Yes	National	Report	Apr	General population	Random	HH/C samples	1071	1.1% (0.5-1.8)	ELISA	Not reported	Not reported	Not reported	Not reported	6	Medium
10	8	Statens Serum Institut (94) (62)	Denmark	Copenhagen; Aarhus; Aalborg; Næstved; Odense	EU/EEA	Yes	National	Report	7 May - 9 Jun; 14 Aug - 1 Oct	General population	Random	HH/C samples	2444; 18000	1.2 (0.7-1.7); 2.2 (1.8 -2.6)	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	Not reported	Not reported	Not reported	9	Low
11	9	Petersen (95)	Denmark	Faroe Islands	EU/EEA	Yes	Regional	Published	27 Apr - 1 May	General population	Random	HH/C samples	1500	0.7% [§]	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	IgM; IgG	94%	100%	9	Low
12	10	Jõgi (96)	Estonia	Tallinn; Saaremaa	EU/EEA	No	Regional	Pre-print	8 May - 31 Jul	General population	Random	HH/C samples	Total 1960; Tallin: 1006; Saaremaa: 954;	Tallinn: 1.5% [§] ; Saaremaa: 6.7% [§]	CMIA; CLIA; LIPS; LFA;	Abbott Laboratories Liaison; In-house Biosensor	IgG; IgG; NA IgM/IgG	92.7%	99.9%	12	Low
13	11	Finnish Institute for Health and Welfare - THL (14)	Finland		EU/EEA	No	National	Report	13 Apr - 28 Dec	General population	Random	HH/C samples	4863	*see report	FMIA	In-house	Not reported	Not reported	Not reported	7	Low
14	12	Carrat (97)	France	Ile-de-France; Grand Est; Nouvelle-Aquitaine;	EU/EEA	Yes	National	Pre-print	4 May - 23 Jun	General population	Random	HH/C samples	14628	Ile-de-France: 10%; Grand Est: 9.0%; Nouvelle-Aquitaine: 3.1%;	ELISA; MN	EUROIMMUN; In-house	IgG	ELISA-S=97.9%; ELISA-NP=50.3%; SN=41.4%	ELISA-S=97.7%; ELISA-NP=99.5%; SN=99.5%	9	Low

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13	Zakhashvili (15)	Georgia	Martvili; Kobuleti; Borjomi; Khelvachauri	non-EU/EEA	Yes	National	Not yet published	1 – 14 Aug 2020; 1 – 14 Dec 2020	General population	Random	HH/C samples	1218; 1219	August: 0%; 0.7%; 1.3%	ELISA; CMIA	Wantai Total Ab ELISA; Roche Diagnostics	Total Abs; Total Abs;	Not reported	Not reported	N/A																																					
14	Tsertsvadze (41)	Georgia	Tbilisi	non-EU/EEA	No	City/local	Pre-print	18-27 May	General population	Convenience	HH/C samples	1068	1.02% (0.38-2.18) §	LFA	Zhejiang Orient Gene Biotech	IgG	93.1%	99.2%	6	Medium																																				
15	Aziz (98)	Germany	Bonn	EU/EEA	Yes; No	City/local	Published^	24 Apr - 30 Jun	General population	Convenience	Group 1: HH/C samples (Rhineland study); Group 2: Voluntary	Group 1: 4771; Group 2: 360;	0.97% (0.72-1.30%) 1.94% (0.84-4.42%)	ELISA	EUROIMMUN	IgG	Not reported	Not reported	7	Low																																				
16	Streeck(53)	Germany	Heinsberg	EU/EEA	Yes	City/local	Published^	31 Mar - 4 Jun	General population	Random	HH/C samples	919	14.1% (11.15% - 17.27%) §	ELISA	EUROIMMUN;	IgA; IgG	90.9%	99.1%	10	Low																																				
17	Santos-Hövenner (54)	Germany	Kupferzell	EU/EEA	Yes	City/local	Published	20 May - 9 Jun	General population	Random	HH/C samples	2203	12% (10.4-14%) §	ELISA	EUROIMMUN	IgG	88.3%	99.2%	10	Low																																				
18	Weis (99)	Germany	Thuringia	EU/EEA	No	Regional	Published	12-22 May	General population	Random	HH/C samples	626	8.4%	ELISA; ELISA; CLIA; CMIA; CLIA; CLIA	EUROIMMUN; Epitope Diagnostics Inc. DiaSorin Abbott Laboratories Roche Diagnostics Snibe Co. Abbott Laboratories	IgG	Not reported	Not reported	10	Low																																				
19	Merkely (100)	Hungary		EU/EEA	Yes	National	Published	1-16 May	General population	Random	HH/C samples	10474	0.68 (0.5-0.86)	CMIA	Abbott Laboratories	IgG	Not reported	Not reported	6	Medium																																				
20	Pagani (43)	Italy	Castiglione D'Adda	EU/EEA	Yes	City/local	Published	18 May - 7 Jun	General population	Random	HH/C samples	509	22.6% (17.2-29.1)	CMIA; LFA	Abbott Laboratories ; Prima Lab	IgG	Not reported	Not reported	9	Low																																				
21	Stefanelli (36)	Italy	Trento	EU/EEA	Yes	Regional	Published	5-15 May	General population	Random	HH/C samples	6075	25.7% §	CMIA	Abbott Laboratories	IgG	99.60%	100%	10	Low																																				
22	Guerriero (101)	Italy	Verona	EU/EEA	Yes	City/local	Published	24 Apr - 8 May	General population	Random	HH/C samples	1515	2.6%	CMIA	Abbott Laboratories	IgG	81.80%	99.30%	8	Low																																				
23	Cito (102)	Italy	Villa Caldari, Abruzzo region	EU/EEA	Yes	Regional	Published	18-19 Apr	General population	Random	HH/C samples	687	10.9% (8.8-13.5%)	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	Total Abs	93%	100%	9	Low																																				
24	Zuridin & Tatyana (34)	Kyrgyzstan	Bishkek City; Osh City; Chui; Osh; Jalal-Abad; Batken; Issyk-Kul; Naryn; Talas	non-EU/EEA	Yes	National	Not yet published	4 Jul – 12 Aug	General population	Random	HH/C samples	4780	32.5%	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	Total Abs	95%	100%	N/A	N/A																																				
25	Snoeck (103)	Luxembourg		EU/EEA	Yes	National	Pre-print	15 Apr - 5 May	General population	Random	HH/C samples	1862	IgG: 2.09% (1.37-2.82) § IgA: 11.07% (9.54-12.60) §	ELISA	EUROIMMUN;	IgG; IgA;	85.7%; 92.2%;	97.8%; 89.2%; 1	8	Low																																				
26	Vos (33)	Netherlands		EU/EEA	No	National	Published	31 Mar - 11 May	General Population	Random	HH/C samples	3207	2.8% (2.1 - 3.7) §	Fluorescent bead-based multiplex immunoassay	In-house	IgG	84.40%	Not reported	10	Low																																				
27	Popova (104)	Russian Federation	Irkutsk Region	non-EU/EEA	No	Regional	Published	28 Jun - 19 Jul	General population	Random	HH/C samples	2674	5.8% (5.3- 6.2)	ELISA	In house	IgG	Not reported	Not reported	8	Low																																				
28	Popova (105)	Russian Federation	Leningrad	non-EU/EEA	No	Regional	Published	23 Jun - 26 Jun	General population	Random	HH/C samples	3130	20.70%	ELISA	In house	IgG	Not reported	Not reported	8	Low																																				
29	Barchuk (37)	Russian Federation	Saint-Petersburg	non-EU/EEA	Yes	City/local	Published^	27 May - 26 Jun	General population	Random	HH/C samples	1038	9.0% CMIA; 10.8% ELISA §	ELISA; CMIA	CoronaPass; Abbott Laboratories	IgG; Total Abs	98.7%; 100%	100%; 99.6%	12	Low																																				
30	Popova (106)	Russian Federation	Saint-Petersburg	non-EU/EEA	No	City/local	Published	15 Jun - 20 Jun	General population	Random	HH/C samples	2713	26% (24.3–27.7)	ELISA	In house	IgG	Not reported	Not reported	8	Low																																				

Study ID	Author	Country	Region	Population	Study Design	Date	Sample Size	Prevalence	Method	Assay	Specificity	Sensitivity	PPV	NPV	LR+	LR-	Number of Studies	Quality Score		
32	Pollan (107)	Spain		non-EU/EEA	Yes	National	Published	8 - 21 Jun	General population	Random	HH/C samples	2758	24.5% (22.9- 26.1)	ELISA	In house	IgG	Not reported	Not reported	8	Low
33	Public Health Agency of Sweden (108)	Sweden	Rinkeby-Kista district, Stockholm	EU/EEA	Yes	City/local	Report	22 Jun - 24 Jun	General population	Random	HH/C samples	538	18.7% (95% CI 14.8-23.3)	CMIA; CLIA; LIPS; LFA;	Abbott Laboratories; Zhejiang Orient Gene Biotech	IgG	100	99.6	11	Low
34	Roxhed (57)	Sweden	Stockholm	EU/EEA	Yes	City/local	Published^	mid-Apr - mid-May	General population	Random	HH/C samples	878	12.5% (95% CI: 10.3%-14.7%)	ELISA	In house	IgM; IgG	100%	98%	7	Low
35	Richard (38)	Switzerland	Canton of Geneva	non-EU/EEA	Yes	Regional	Pre-print	6 Apr - 30 Jun	General population	Random	HH/C samples	8344	7.8% (6.8-8.9)	ELISA	EUROIMMUN	IgG	93%	100%	10	Low
36	Bi (109)	Switzerland	Geneva	non-EU/EEA	Yes	City/local	Pre-print	3 Apr - 30 Jun	General population	Random	HH/C samples	4354	6.6%	ELISA	EUROIMMUN	IgG	93%	99%	9	Low
37	Stringhini (32)	Switzerland	Geneva	non-EU/EEA	Yes	City/local	Published	6 April - 9 May	General population	Random	HH/C samples	2766	1stweek: 4-8% (2-4-8-0); 2nd week: 8-5% (5-9-11-4); 3rd week: 10-9% (7-9-14-4); 4th week: 6-6% (4-3-9-4); 5th week: 10-8% (8-2-13-9)	ELISA	EUROIMMUN	IgG	93%	100%	9	Low
38	Ward (47)	United Kingdom	England	non-EU/EEA	No	National	Pre-print	20 Jun - 13 Jul; 31 Jul - 13 Aug; 15 Sept - 28 Sept	General population	Random	HH/C samples	99908; 105829; 159367	5.96 (5.78-6.14); 4.83 (4.67-5.00); 4.38 (4.25-4.51) §	LFA	Fortress Diagnostics	IgG	84.4%	98.6%	9	Low
39	Wells (110)	United Kingdom	London; South East England	non-EU/EEA	Yes	Regional	Published	27 Apr - 2 Jun	General population	Convenience	HH/C samples	431	12% (9.1-15.2)	CLIA; CMIA	Abbott Laboratories; Roche Diagnostics	IgM; IgG	90%	100%	6	Medium
Residual sera																				
40	Herzog (56)	Belgium	Wallonia Flanders; Brussels	EU/EEA	Yes	National	Pre-print	30 Mar - 5 Apr; 20 Apr - 26 Apr; 18 May - 25 May; 8 Jun - 13 Jun; 29 Jun - 4 Jul	General population	Convenience	Residual sera	Total: 15529; 3910; 3397; 3242; 2960; 3023;	2.9% (2.3-3.6%); 6.0% (5.1-7.1%); 6.9% (5.9-8.0%); 5.5% (4.7-6.5%); 4.5% (3.7-5.4%)	ELISA	EUROIMMUN;	IgG	64.5 - 87.8%	99.20%	5	Medium
41	Tsaneva-Damyanova (111)	Bulgaria	Varna city; North East Bulgaria	EU/EEA	Yes	Regional	Published	26 Mar - 20 Apr	General population	Convenience	Residual sera	586	4.8% overall; 1.0% IgM, 1.2% IgG 2.6% IgM and IgG	LFA	Zhejiang Orient Gene Biotech	IgM; IgG	85%	96%	4	Medium
42	Bloomfield (112)	Czech Republic	Prague	EU/EEA	Yes	City/local	Published	3 Jul - 19 Aug	General population	Convenience	Residual sera (Children)	200	0% (0-0.5%)	ELISA; CLIA	EUROIMMUN; Roche Diagnostics	IgA; IgG	EUROIMMUN: IgA=98.6%; IgG=94.4%; Elecsys=99.5%;	EUROIMMUN: IgA=92%; IgG=99.6%; Elecsys=99.8%;	3	High
43	Krleza (63)	Croatia	Zagreb	EU/EEA	No	National	Published^	13 - 29 May ; 24 Oct - 23 Nov	General population	Convenience	Residual sera (Children)	240; 308	2.9%; 8.4%	ELISA; CLIA; MN	Vircell; Roche Cobas Elecsys; In-house	Not reported	Not reported	Not reported	3	High
44	Capai (113)	France	Corsica	EU/EEA	Yes	Regional	Published	16 Apr - 15 Jun	General population	Convenience	Residual sera	1973	5.5% (4.5-6.6%) §	ELISA; MN	EUROIMMUN; In-house	IgG	Not reported	Not reported	8	Low
45	Cohen (114)	France		EU/EEA	Yes	City/local	Pre-print	14 Apr - 12 May	General population	Convenience	Residual sera (Children)	605	10.7% (8.4-13.5)	LFA	Biosynex BSS test	IgM; IgG	91.8%	99.2%	5	Medium
46	Le Vu (61)	France		EU/EEA	Yes	National	Published^	9 Mar - 15 Mar; 6 Apr - 12 Apr; 11 May - 17 May;	General population	Convenience	Residual sera	Total: 11 021; 3834; 3595; 3592;	March:0.41% [0.05-0.88] §; April: 4.14% [3.31-4.99] §; May: 4.93% [4.02-5.89] §	LuLISA; MN	In-house; In-house;	IgG; NT-Abs	LuLISA N=86%; LuLISA S=96%	LuLISA N=100%; LuLISA S=100%	13	Low



Study ID	Author(s)	Country	Region	EU/EEA	Yes/No	Level	Status	Period	Population	Convenience	Sample Size	Prevalence	Method	Lab	Antibody	Sensitivity	Specificity	Accuracy	Prevalence	CI	
47	Bogianni dou (115)	Greece		EU/EEA	Yes	National	Published	1 Mar - 30 Apr	General population	Convenience	6586	March = 0 (0-0.23%) [†] ; April=0.23% (0-0.48%) [‡]	ELISA; ELISA; CMIA	EUROIMMUN; Viacell; Abbott Laboratories	IgG	84%	99.7%		8	Low	
1	48	Gudbjartsson (13)	Iceland	EU/EEA	Yes	Regional; National	Published	18 Feb - 9 Mar	General population	Convenience	470; 24115	0%; Residual sera: 0.30% (0.2 - 0.4) §; Reykjavik: 0.4% (0.3 - 0.6)	ELISA; ELISA; ELISA; CLIA	EUROIMMUN; EDI/Eagle; Roche Diagnostics	IgA; IgM; IgG	Not reported	99.80%		9	Low	
4	49	Public Health Agency of Sweden (65, 66)	Sweden	EU/EEA	No	National	Report	20 Apr to 12 Jun; 12 Oct to 23 Oct; Nov 23 to 4 Dec	General population	Convenience	4500 per collection period	20 April-26 April: 5.3% (3.8-7.1); 27 April-3 May: 4% (2.71-5.67); 4 May - 10 May: 3.9% (2.61-5.42); 11-17 May: 4.5% (3.07-6.15); 18-24 May: 5.2% (3.67-7); 25-31 May: 5.7% (3.98-7.72); 1-7 June: 6.8% (5.07-8.80); 8-14 June: 5.2% (3.74-7.06); 12-23 October: 6.7% (5.67-7.79); 23 November to 4 December: 7.9% (6.79-9.19);	Not reported	Sci Life Lab / KTH	Not reported	98.9	99.4		6	Low	
15	50	Posfay-Barbe (116)	Switzerland	Geneva	non-EU/EEA	No	City/local	Published	1-30 Apr	General population	Convenience	208	ELISA: 9.1%; LFA: 12.5%	ELISA; LFA	EUROIMMUN	IgG	Not reported; 88.9%	Not reported; 94.7%		2	High
17	51	Dickson (117)	United Kingdom	Scotland	non-EU/EEA	Yes	National	Published	20 Apr - 15 Jun	General population	Convenience	4751	4.3% (4.2-4.5)	CLIA	DiaSorin Liaison	IgG	87.5%	98.6%		3	High
18	52	Public Health Scotland (64)	United Kingdom	Scotland	EU/EEA	Yes	National	Report	20 Apr - 17 May; 18 May - 14 Jun; 15 Jun - 12 Jul; 13 Jul - 9 Aug;	General population	Convenience	2039; 2172; 2709; 2882	4.1% (2.4%, 5.7%); 3.4% (1.8%, 5.0%); 3.9% (2.3%, 5.4%); 3.7% (2.2%, 5.2%)	CMIA	DiaSorin Liaison	Not reported	Not reported	Not reported	4	Medium	
Blood donors																					
25	53	Musa (40)	Bosnia and Herzegovina	Federation of Bosnia and Herzegovina	non-EU/EEA	Yes	Regional	Not yet published	1 Nov - 7 Dec	Blood donors	Convenience	1015	19.1% (16.7-21.5)	CMIA	Abbott Laboratories	Total Abs;	Not reported	Not reported	N/A	N/A	
27	54	Pedersen (35)	Denmark	Danish Capital Region; Zealand Region; Central Denmark Region	EU/EEA	Yes	National	Published	2 Jun - 19 Jun	Blood donors	Convenience	Total: 2311; 17-69yrs: 1110; >70yrs: 1201	17-69yrs: 2.5 (1.3-3.8) [§] >70yrs: 1.4 (0.3-2.5) [§]	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	Total Abs;	96.7% (92.4-98.6)	99.5% (98.7-99.8)		7	Low
31	55	Erikstrup (118)	Denmark		EU/EEA	Yes	National	Published [^]	6 Apr - 3 May	Blood donors	Random	20 640	2.0% (95% CI, 1.8-2.2%); 1.9% (95% CI, 1.8-2.3) [‡]	LFA	Livzon Diagnostics Inc	IgM; IgG	82.6%	99.5%		7	Low
32	56	Bloddonor (119)	Denmark		EU/EEA	No	National	Report	5 Oct - 31 Dec	Blood donors	Convenience	71883	October : 2.1% (1.1-2.7) ; October : 1.9% (0.9-2.5) ; October : 2.3% (1.3-2.8) ; October : 2.1% (1.1-2.7) ; November : 2.2% (1.2-2.7) ; November : 2.7% (1.6-3.2) ; November : 2.8% (1.7-3.4) ; November : 3.2% (2.1-3.8) ; December : 3.2% (2.2-3.9) ; December : 2.9% (1.8-3.5) ;	LFA	Livzon	Not reported	Not reported	Not reported	4	Medium	



1																					
2																					
3																					
4																					
5																					
6																					
7	57	Gallian (46)	France	Haut-Rhin departmental area [DA]; Seine-Saint-Denis DA; Bouches-du-Rhône DA; Oise DA; Lille	EU/EEA	No	National	Published	23 Mar - 5 Apr	Blood donors	Convenience	Blood donors	998	2.71%	MN	In-house	NT-Abs	Not reported	100%	6	Medium
8																					
9																					
10																					
11	58	Grzelak (120)	France		EU/EEA	No	City/local	Published	20-24 Mar	Blood donors	Convenience	Blood donors	200	3%	ELISA; LIPS; MN	In-house; In-house; In-house;	IgA; IgG; IgM	Not reported	Not reported	3	High
12																					
13																					
14	59	Fischer (121)	Germany	Hesse; Lower Saxony; North Rhine-Westphalia	EU/EEA	Yes	National	Published	Mar - Jun	Blood donors	Convenience	Blood donors	3186	0.91% (0.58-1.24)	ELISA; CLIA; CMIA	EUROIMMUN; Diasorin Liaison; Abbott Laboratories	IgG	65%	99-100%	4	Medium
15																					
16																					
17	60	Runkel (17)	Germany	Southwest	EU/EEA	Yes	Regional	Published	Mar - Jun	Blood donors	Convenience	Blood donors	3754	0.40%	ELISA; CLIA; CMIA	Epitope Diagnostics; IDK5000 Immundiagnostik AG; Abbott Architect; Roche Diagnostics	IgG	Not reported	Abbott=99.6%; IDK5000=99.1%; EDI=96.4%	7	Low
18																					
19																					
20																					
21	61	Percivalle (122)	Italy	Lombardy	EU/EEA	Yes	City/local	Published	18 Mar - 6 Apr	Blood donors	Convenience	Blood donors	390	23%	MN	In-house	NT-Abs	95%	100%	6	Medium
22																					
23																					
24	62	Fiore (44)	Italy	South East	EU/EEA	No	Regional	Published	1-31 May	Blood donors	Convenience	Blood donors	904	0.99%	CLIA	Snibe Co., Ltd.	IgM; IgG	IgM=78.65%; IgG=91.21%	IgM=97.5%; IgG=97.3%	4	Medium
25																					
26	63	Valenti (58)	Italy	Milan	EU/EEA	Yes	City/local	Pre-print	24 Feb - 8 Apr	Blood donors	Convenience	Blood donors	789	February/March: 2.7% (95% 0.3-6.0%) ; March/April: 5.2% (2.4-9.0)§	LFA	Prima Lab	IgM; IgG	IgM=68%; IgG=100%	10	Low	
27																					
28	64	Slot (48)	Netherlands		EU/EEA	Yes	National	Published	1-15 Apr	Blood donors	Convenience	Blood donors	7361	3.40%	ELISA	Beijing Wantai Biological Pharmacy Enterprise; Zhejiang Orient Gene Biotech	IgA; IgM; IgG	100%	99.1-100%	5	Medium
29																					
30																					
31	65	Lundkvist (18)	Sweden	Djurgårdsstaden and Tensta (Stockholm)	EU/EEA	Yes	City/local	Published	17-18 Jun	Blood donors	Random	Blood donors	213	Djurgårdsstaden: 4.1% (0.6-7.6%); Tensta: 30.0% (20.3-39.7%)	LFA	Zhejiang Orient Gene Biotech	IgM; IgG	IgM=100%; IgG=100%	IgM=100%; IgG=95.5%	6	Medium
32																					
33	66	Public Health England (67-72)	United Kingdom	England	non-EU/EEA	Yes	National	Report	23 Mar - 3 Dec	Blood donors	Convenience	Blood donors	1000 samples/week/region	6 May - 29 May: 8.3 (7.5-9.2) 4 June - 29 June: 7.6 (6.9-8.4) 29 June - 28 July: 5.9 (5.3-6.5) 20 July - 16 August: 5.5 (4.9-6.1); 13 August - 6 September: 5.8 (5.1-6.4); 24 August - 18 September: 6.1 (5.4 - 6.8); 21 October - 13 November: 6.0% (5.4 - 6.6); 16 November - 13 December: 6.9% (6.3 - 7.6)§	ELISA	EUROIMMUN	IgG	79%	99%	4	Medium
34																					
35																					
36																					
37																					
38																					
39																					
40	67	Thompson (123)	United Kingdom	Scotland	non-EU/EEA	Yes	National	Published	17 Mar - 18 May	Blood donors	Convenience	Blood donors	3500	3.17%	CLIA; CMIA	Abbott Laboratories; Roche Diagnostics	IgM; IgG	94.1%	100%	8	Low
41																					
42																					
43																					
44																					
45																					
46																					
47																					

68	Public Health Scotland (64)	United Kingdom	Scotland	EU/EEA	Yes	National	Report	29 Jun - 9 Aug	Blood donors	Convenience	BMJ Open	3220	3.1% (2.5%, 3.8%)	Not reported	Not reported	Not reported	Not reported	Not reported	5	High	
1 Patients seeking healthcare (non-COVID-19)																					
2	69	Fogel (124)	France	Paris	EU/EEA	No	City/local	Published	1 Jun - 31 Aug	General population	Convenience	Patients seeking care (non-COVID-19)	249	2.8%	CMIA	Abbott Laboratories	IgG	Not reported	Not reported	2	High
3	70	Choi (125)	Germany	Berlin	EU/EEA	No	City/local	Published	19 Mar - 19 May	General population	Convenience	Patients seeking care (non-COVID-19)	223	7.20%	ELISA; IFIT; PRNT	EUROIMMUN; In house; In house	IgA; IgG	Not reported	Not reported	1	High
5	71	Rauber (126)	Germany	Heidelberg	EU/EEA	No	City/local	Published	5 May - 8 Jun	General population	Convenience	Patients seeking care (non-COVID-19)	219	3.2%	ELISA	EUROIMMUN	IgG	94.6%	99.8%	1	High
7	72	Zambelli (29)	Italy	Bergamo	EU/EEA	No	City/local	Published	1-30 Apr	General population	Convenience	Patients seeking care (non-COVID-19)	560	31%	LFA	Moers	IgM; IgG	Not reported	Not reported	2	High
9	73	Medas (127)	Italy	Cagliari	EU/EEA	No	City/local	Published	31 Mar - 30 Jun	General population	Convenience	Patients seeking care (non-COVID-19)	86	5.8%	CLIA	Snibe Co., Ltd	IgM; IgG	Not reported	Not reported	1	High
10	74	Capasso (128)	Italy	Campania Region	EU/EEA	No	Regional	Published	11 May - 15 Jun	General population	Convenience	Patients seeking care (non-COVID-19)	310	2.90%	LFA	Shanghai Kehua LFAI	IgM; IgG	66%	96.60%	4	Medium
12	75	Cento (129)	Italy	Milan	EU/EEA	No	City/local	Published	11 May - 5 Jul	General population	Convenience	Patients seeking care (non-COVID-19)	2753	5.1% (4.3%-6.0%)	CLIA; CLIA	Abbott Laboratories DiaSorin Liaison In house	IgG	84.2-100%	99.6-100%	4	Medium
14	76	Berte (130)	Italy; Germany	Milan and Cagliari; Erlangen	EU/EEA	No	Regional	Published	Apr - Jun	General population	Convenience	Patients seeking care (non-COVID-19)	354; Milan, Italy: 129; Cagliari, Italy: 48; Erlangen, Germany: 177	2.3% (0.8- 3.8)	ELISA		IgA; IgG	IgA=71.4%; IgG=97.64%	IgA=99.8%; IgG=95.2%	4	Medium
17	77	Vena (45)	Italy	Liguria; Lombardia	EU/EEA	No	Regional	Published	Mar - Apr	General population	Convenience	Patients seeking care (non-COVID-19)	3609	11% (10.0-12.1)	CLIA; LFA; LFA	MaglumiTM; Realy tech; Biosynex BSS	IgM; IgG	IgM=78.6-100%; IgG=90.6-100%	IgM=88.7-97.5%; IgG=90.6-100%	4	Medium
20	78	Cabezón-Gutiérrez (30)	Spain	Madrid	EU/EEA	No	City/local	Published	29 May - 19 Jun	General population	Convenience	Patients seeking care (non-COVID-19)	229	31.40%	LFA	Hangzhou Testsea Biotechnology	IgM; IgG	IgM=88%; IgG=96%	IgM=100%; IgG=100%	4	Medium
21	79	Prados (131)	Spain		EU/EEA	No	National	Published	27 Apr - 26 Jun	General population	Convenience	Patients seeking care (non-COVID-19)	6140	0.70%	ELISA	EDI Epitope Diagnostics	IgM; IgG	Not reported	Not reported	3	High
23	80	Clarke (28)	United Kingdom	London	non-EU/EEA	No	City/local	Published	27 Apr - 7 May	General population	Convenience	Patients seeking care (non-COVID-19)	356	36.2%	CMIA	Abbott Laboratories	IgG	Not reported	Not reported	3	High
24	81	Predecki (132)	United Kingdom	London	non-EU/EEA	No	City/local	Published	1-30 Jun	General population	Convenience	Patients seeking care (non-COVID-19)	855	8.1% (95% CI, 6.4 to 10.1); 10.4% (8.5 - 12.6%) CMIA + LFA results	CMIA; LFA	Abbott Laboratories; Fortress Diagnostics	IgG	90.6%; 96.5%	Not reported	4	Medium
27 Pregnant or parturient women																					
28	82	Egerup (19)	Denmark	Copenhagen	EU/EEA	No	City/local	Published	4 Apr - 3 Jul	General population	Convenience	Pregnant or parturient women; Partners: Newborns	Total: 3707; Pregnant or parturient women: 1313 Partners: 1188; Newborns: 1206	Pregnant or parturient women: 2.6% (1.7-4.0)* Partners: 3.5% (2.3 - 5.1)* Newborns: 1.4%*	CLIA	Shenzhen Yhlo Biotech	IgM; IgG	IgM=42%; IgG=94%	IgM=99.7%; IgG=99.3%	7	Low
32	83	Mattern (20)	France	Paris	EU/EEA	Yes	City/local	Published	4-31 May	General population	Convenience	Pregnant or parturient women	249	8%	CMIA	Abbott Laboratories	IgG	Not reported	Not reported	3	High
34	84	Tsatsaris (21)	France	Paris	EU/EEA	Yes	City/local	Published	29 Apr - 26 Jun	General population	Convenience	Pregnant or parturient women	529	4.7% (3.0-6.7%)	CMIA	Abbott Laboratories	IgG	92.7 - 97.3 %	>99%	3	High
35	85	Cosma (22)	Italy	Turin4/6/2020	EU/EEA	No	City/local	Published	16 Apr - 4 Jun	General population	Convenience	Pregnant or parturient women	138	5.80%	CLIA; LFA; LFA	DiaSorin Liaison; Boditech; AFIAS	IgM; IgG	Not reported	Not reported	2	High
38	86	Crovetto (23)	Spain	Madrid	EU/EEA	Yes	City/local	Pre-print	14 Apr - 5 May	General population	Convenience	Pregnant or parturient women	874	14.3%	CLIA	Vircell	IgA; IgM; IgG	IgM/IgA=89 %; IgG=70%	IgM/IgA=99 %; IgG=89%	2	High
39	87	Villalain(24)	Spain	Madrid	EU/EEA	No	City/local	Published	28 Feb - 10 May	General population	Convenience	Pregnant or parturient women	769	11.2%	ELISA	In house	IgG	Not reported	Not reported	2	High
41	88	Lumley (25)	United Kingdom	Oxford	non-EU/EEA	Yes	City/local	Published	14 Apr - 15 Jun	General population	Convenience	Pregnant or parturient women	1000	5.3% (4.0-6.9)	CLIA	In house	IgG	99.1%	99%	4	Medium

Other/Multiple populations

1	89	Krátká (133)	Czech Republic	Stratonice; Pisek	EU/EEA	No	Regional	Published	4-15 May	Other	Not reported	Employees	2011	Stratonice 2.9%; Pisek 1.9%	ELISA	EUROIMMUN; N;	IgA; IgG	IgA=98.6%; IgG=94.4%	IgA=92%; IgG=99.6%	5	Medium
2	3	Jerkovic (134)	Croatia	Split-Dalmatia; Sibenik-Knin County	EU/EEA	No	Regional	Published	23-28 Apr	Other	Convenience	Employees - voluntary	1494	1.27% (0.8-2.0%)	LFA	AMP Diagnostics	IgM; IgG	IgM=95.7%; IgG= 91.8%	IgM=97.3%; IgG=96.4%	6	Medium
4	5	Vince (51)	Croatia		EU/EEA	No	National	Pre-print	20 May - 31 Jul	Other	Convenience	Football players	305	20%	ELISA	EUROIMMUN; N;	IgA; IgG	Not reported	Not reported	2	High
6	92	Anna (135)	France	Ile-de-France; Paris; Saint-Cloud; Orsay	EU/EEA	No	City/local	Published	28 Apr - 31 Jul	Other	Convenience	Employees - voluntary	1847	11.6%	LuLISA; MN	In-house; In-house;	IgG	Not reported	98%	6	Medium
9	93	Fontanet (52)	France	Oise	EU/EEA	No	City/local	Published^	30 Mar – 4Apr; 28 Mar – 30 Apr	Other	Convenience	HH/C samples; High school; Primary school	664 1340	25%; 10%	ELISA; S-flow LIPS;	In-house; In-house; In-house	IgG	99.4%	>99%	8	Low
11	94	Roederer (16)	France	Paris	EU/EEA	No	City/local	Published^	23 Jun - 2 Jul	Other	Convenience	Persons experiencing homelessness	818	52%	LuLISA* ; MN	In-house	IgG	Not reported	97-100%	9	Low
13	95	Krähling (136)	Germany	Frankfurt am Main	EU/EEA	No	City/local	Pre-print	6-14 Apr	Other	Convenience	Employees	998	2.90%	ELISA	In-house;	IgG	87.2-100%	99.2%	4	Medium
14	96	Mack (60)	Germany		EU/EEA	No	National	Published	May; June	Other	Convenience	Professional football teams	1184	May: 1.99% (1.33–2.97); June: 2.09% (1.37–3.17);	ELISA; CLIA	EUROIMMUN; Roche Diagnostics	IgG	Not reported	Not reported	3	High
16	97	Ceban (137)	Republic of Moldova		non EU/EEA	Yes	National	Not yet published	17 Nov 2020 – 15 Jan 2021	Other	Random	Hospital visitors	5656	48.4%	ELISA	Beijing Wantai Biological Pharmacy Enterprise Virell	Total Ab	Not reported	Not reported	N/A	N/A
19	98	Gujski (138)	Poland	Mazowieckie Province	EU/EEA	No	Regional	Published	22 Jun - 8 Jul	Other	Random	Employees	5082	4.30%	ELISA		IgA; IgM; IgG	65% - 97%	82% - 96%	3	High
20	99	Pérez-García (55)	Spain	Madrid	EU/EEA	No	City/local	Published	5 Mar - 30 May	Other	Convenience	Employees	2963	22.40%	LFA	AllTest Biotech	IgM; IgG	88%	100%	4	Medium
22	100	Ulyte (73)	Switzerland	Canton of Zurich	non-EU/EEA	No	Regional	Published^	16 Jun - 9 Jul; 26 Oct - 19 Nov	Other	Random	School children	5155; 2603; 2552	7.8% (6.2% to 9.5%); 2.4% (1.4-3.5); 4.5% (3.2-6.0);	ELISA	In-house	IgA; IgM; IgG	93.3-94.3%	99-99.6%	6	Medium
24	101	Roarty (139)	United Kingdom	Belfast; Cardiff; Glasgow; London; Manchester	non-EU/EEA	No	National	Published	26 Jun - 15 Aug	Other	Convenience	Children of employees	849	7.66% (6.05-9.64)	CLIA; CLIA	Elecsys Roche; DiaSorin Liaison	IgG	84%; 64%	100%; 98%	4	Medium
28	102	Waterfield (140)	United Kingdom	Belfast; London; Glasgow; Manchester; Cardiff	non-EU/EEA	No	National	Published	16 Apr - 3 Jul	Other	Convenience	Children of employees	992	6.9% (5.4 - 8.6)	CLIA; CMIA	Abbott Laboratories; Roche Diagnostics; DiaSorin Liaison	IgG	64-94%	98-100%	4	Medium
32	103	Armann (59)	Germany	Eastern Saxony	EU/EEA	No	Regional	Pre-print	25 May - 30 Jun; 15 Sept- 13 Oct	Other	Convenience	Teachers and students	1779	0.6%; 0.6%	ELISA; CLIA; CMIA	EUROIMMUN; Diasorin Liaison; Abbott Laboratories	IgG	97.6%	99.3%	7	Low
35	104	Reisinger (141)	Germany	Rostock	EU/EEA	No	City/local	Published	22-29 Apr	Other	Convenience	Children and mothers	401	2.90%	ELISA	EUROIMMUN	IgA; IgG	Not reported	Not reported	3	High
36	105	Tsitsilonis (42)	Greece	Athens	EU/EEA	No	City/local	Published	15 Jun - 15 Jul	Other	Convenience	Employees and students	2500	0.93% (0.27, 2.09) §	CLIA	Roche Diagnostics	Total Abs	100%	99.81%	5	Medium
38	106	Lastrucci (142)	Italy	Prato	EU/EEA	No	Regional	Published	1 May - 31 May	Multiple	Random	Work-from-home; Support service	1828	1% (0.3-2.0); 1.4% (0.7-2.2)	LFA	Hangzhou Laihe Biotech	IgM; IgG	Not reported	Not reported	2	High
39	107	Soriano (143)	Spain	Madrid	EU/EEA	Yes	City/local	Published	27 Apr - 17 May	Multiple	Convenience	University staff, family members, community	674	13.8%	LFA	PCL Inc	IgM; IgG	Not reported	Not reported	3	High

Study ID	Country	Region	EU/EEA	Initial Report	Study Type	Publication Status	Time Period	Study Design	Recruitment	Study Population	Sample Size	Prevalence	Assay	Setting	Antibody	Sensitivity	Specificity	Number of Studies	Quality	
108	Montenegro (31)	Spain	Barcelona	EU/EEA	No	City/local	Published	21-24 Apr; 29 Apr - 6 May	Multiple	Random	311; 634	5.47% (3.44-8.58); 38.49% (34.78%-42.33%)	LFA; LFA; LFA	Livzon; Lysine; Sure Screen	IgM; IgG	Livzon=91.2%; Lysine=98.6%; SureScreen=91%	100%	Not reported	9	Low
109	Emmenegger (27)	Switzerland	Canton of Zurich	non-EU/EEA	Yes	Regional	Pre-print	Mar - Jul	Multiple	Convenience	Total: 33932; Blood donor cohort: 9,102; Patient cohort: 24,830;	BDS cohort [†] : April: 1.2%; May: 1.6%; July: 0.7%; Patient cohort [†] : March: 0.3%; April: 1.4%; May -July: 0.9%;	Tripartite Automated Blood Immunoassay (TRABI)	In house	IgG	100%	100%	5	Medium	
110	Dopico (26)	Sweden	Stockholm	EU/EEA	No	City/local	Published [^]	4 Mar - 11 Dec	Multiple	Convenience	2600, 2500	14.8% (12.2-18.0)	ELISA	In house	IgG	Spike 3SD:100% (95% CI [97.5-100.0]); Spike 6SD:100% (95% CI [97.5-100.0]); RBD 3SD:100% (95% CI [97.5-100.0]); RBD 6SD:98.0% (95% CI [94.2-99.3]);	Spike 3SD: 99.0% (95% CI [98.6-99.0]); Spike 6SD: 99.9% (95% CI [99.6-100.0]); RBD 3SD: 99.0% (95% CI [98.4-99.4]); RBD 6SD: 99.9% (95% CI [99.6-100.0])	5	Medium	
111	Davis (144)	United Kingdom	London	non-EU/EEA	No	City/local	Pre-print	Jun	Other	Convenience	University staff and students	1882	6.6% (5.6-7.8)	LFA	SureScreen	IgM; IgG	89%	100%	4	Medium

* LuLISA: Luciferase Linked Immunosorbent Assay
[^] Initially reported to WHO EURO and ECDC in 2020 or in pre-print form and since published

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3 In total, 72 (65%) of the studies provided representative estimates from the general population, of which
4 sample frames included 45 (41%) studies of household or community samples, 13 (12%) residual sera, 13
5 (12%) patients seeking healthcare for non-COVID-19 related issues, seven (6%) pregnant or parturient
6 women. Sixteen (14%) studies sampled blood donors as a proxy for the general population while 23 (21%)
7 sampled other or multiple populations. Studies were conducted at differing geographical levels within a
8 country, including at the national level (n=33; 30%), regional level (n=27; 24%) and city or local level
9 (n=50; 44%). One study reported both national and regional estimates (13).
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20 Over half of the studies used one serological assay (74; 67%) while 34 (31%) used at least two different
21 assays. In 82 studies (74%), commercial assays from various sources were used, 20 (18%) studies used an
22 in-house assay only and six studies (5%) used both a commercial and in-house developed assay. The test
23 method was not reported in two studies. An Enzyme-linked Immunosorbent assay (ELISA) was the method
24 most commonly employed (n=55, 50%), followed by Chemiluminescent immunoassay (CLIA) or
25 Chemiluminescence Microparticle Immunoassay (CMIA) (n=42, 38%) and lateral flow immunoassays
26 (LFAs) (n=25, 23%). Seventeen studies (15%) used LFAs exclusively. Ten studies (9%) employed in-
27 house microneutralization assays to assess the neutralizing ability of SARS-CoV-2 antibodies.
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39 Of 90 studies that used a commercial assay, 33 studies (37%) reported the use of tests with acceptable
40 sensitivity and specificity. Of those that independently validated assay performance (n=41, 46%), 14 (34%)
41 reported acceptable sensitivity and specificity, while 27 (66%) did not meet these thresholds. Of the 20
42 studies that used an in-house assay, nine (45%) reported an acceptable test performance, four (20%)
43 performed below these thresholds and seven (35%) did not report on test performance. The majority of
44 studies (n=83, 75%) did not report adjustment for test sensitivity or specificity in their analysis.
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Table 1: Study characteristics

Characteristics	Number of studies	%
Total	111	100
Study characteristics		
Country		
WHO European Region (EU/EEA)	82	74
WHO European Region (outside of EU/EEA)	29	26
WHO UNITY alignment		
Unity-aligned	56	50
Not Unity-aligned	55	50
Publication type		
Peer-reviewed article	77	69
Pre-print	19	17
Institutional report	9	8
Not yet published	6	5
Geographical level		
National	33	30
Regional	27	24
City/Local	50	44
Multiple	1	1
Sampling strategy		
Convenience	69	62
Random	41	37
Not reported	1	1
Population type		
Household/Community	45	41
Residual sera	13	12
Blood donors	16	14
Patients seeking healthcare (non COVID-19)	13	12
Pregnant or parturient women	7	6
Other/multiple	23	21
Quality assessment		
Low risk of bias	41	37
Medium risk of bias	40	36
High risk of bias	24	22
N/A	6	5
Sample size		
<1000	45	41
>=1000	66	59
Laboratory characteristics		
Serological method		
ELISA	55	50
CMIA/CLIA	42	38
LFA	25	23
MN	10	9
Other	8	7
Not reported	2	1
Type of assay		
Commercial	90	81
In-house	26	23
Not reported	2	1

*ELISA – Enzyme linked immunoassay; CMIA/CLIA - Chemiluminescence Microparticle Immunoassay/ Chemiluminescence Microparticle Immunoassay; LFA – Lateral flow immunoassay; MN – Microneutralization assay

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3 Based on our quality scoring system (Supplementary Table S2), 81 studies (73%) were of high or medium
4 quality reflecting a low or medium risk of bias, respectively (medium quality: n=40, 36%; high quality
5 n=41, 37%). A total of 24 studies (22%) were determined to be at high risk of bias, largely due to non-
6 random sampling frame, weak representativeness of the general population or lack of adjustment for
7 sampling bias or test performance.
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15 Seroprevalence estimates (n=88) from national studies ranged from 0% (CI: 0.0-0.7) in Finland in May (14)
16 to 51.3% in Georgia in December (15) (median 2.2% (IQR 0.7 – 5.2%); n=124) (Figure 3a), while
17 seroprevalence estimates from studies spanning regions, cities or towns (n=101) ranged from 0% (CI 0.0-
18 0.5%) in Czech Republic in August 2020 (15) to 52% in a Médecins Sans Frontières centre in Paris, France
19 during an outbreak with widespread community transmission in June 2020 (16) (median 5.8% (IQR 2.3-
20 12%); n=101) (Figure 3b).
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31 A total of 45 studies provided seroprevalence estimates (n=105) from community or household samples
32 and 39 studies (87%) were found to be of high or medium quality. Seroprevalence estimates ranged from
33 0% (CI: 0-0.7%) in Finland in May and to 51.3% in December 2020 in Georgia (15) (median 2.6% (IQR
34 0.5-10%) n=105) (Supplementary Figure S1).
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41 Thirteen studies screened residual clinical samples (29-42) between February and November 2020, of
42 which nine (70%) were of high or medium quality. Seroprevalence estimates (n=34) in this population
43 varied across countries ranging from 0% (CI 0-0.23) in Greece in March to 18.7% (CI 16.7-23.3%) in
44 Sweden in June (median 4.5% (IQR 3.5-5.9%); n=34) (Supplementary Figure S2a).
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51 Eighteen studies (17%) utilized blood donors as a proxy for the general population between February and
52 December 2020, of which 16 were of high or medium quality. Seroprevalence estimates (n=42) in blood
53 donors varied across countries, ranging from 0.4% in Germany between March and June (17) to 30% in
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3 Tensta (Stockholm) following a period of high incidence in June (18) (median 5.8% (IQR 2.1-5.7%) n=42)
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5 (Supplementary Figure S2b).
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10 Eight studies investigated the seroprevalence of SARS-CoV-2 in pregnant or parturient women, reporting
11 estimates ranging from 2.6% (CI 1.7-4%) and 14.3% between March and June 2020 (median 6.9% (IQR
12 5.1-12%); n=8) (19-25) (Supplementary Figure S2c). One study provided combined estimates of blood
13 donors and pregnant women of 14.8% in Sweden between March and December (26)
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20 Fourteen studies provided 16 estimates from individuals seeking healthcare for non-COVID-19 related
21 reasons and seven (50%) of these were medium or high quality. Estimates ranged from 0.3% in Zurich,
22 Switzerland in March (27) to 36.2% in London in April (28) (median 4.1% (IQR 2.1-8.8%); n=16) from
23 March to August 2020. The highest seroprevalence estimates (>10%) in this group were observed in three
24 patient groups investigated following local widespread community transmission, oncology patients (31%)
25 in Bergamo, Italy in April 2020 (29), oncology patients (31.4%) in Madrid between May and June 2020
26 (30) and haemodialysis patients (36.2%) in London in April and May 2020 (28) and patients (38.5%) in
27 Barcelona, Spain in April (31) (Supplementary Figure S2d).
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39 Forty-four (41%) studies reported seroprevalence estimates stratified by age. Seroprevalence estimates
40 varied considerably across age groups and estimates tended to be lower in children (<18 years) (32-34)
41 and older age groups (>60 years) (32, 35-40). Whilst a number of studies reported a high seroprevalence
42 in older age groups (>55 years) (36, 37, 41-46), some studies also reported a higher seroprevalence in
43 younger age groups (<40 years) (33, 46-48). In studies that reported seroprevalence estimates by sex,
44 similar seroprevalence results were observed between females and males with the exception of a study in
45 Italy (45), Russian Federation (49) and Kyrgyzstan (34) which each found a higher seroprevalence in
46 females.
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3 A number of studies provided seroprevalence estimates prior to, or at the early stages of the epidemic in
4 the country (Supplementary Figure S3). Of these, overall study estimates were largely below 10%, however
5 higher seroprevalence was noted in a number of population-specific, regional or local studies (29, 36, 43,
6 50-54), with suggestion of earlier undetected transmission in some countries (24, 26, 34, 55). A total of
7 16 studies reported seroprevalence estimates spanning multiple timepoints or stages of the epidemic (14,
8 15, 27, 31, 32, 47, 56-73). In a serial cross-sectional study in France (61), residual blood sampled before,
9 during and after a national lockdown showed a seroprevalence of 0.41%, 4.14%, and 4.93%, respectively.
10 In Georgia, in a community sample, an increase in seroprevalence from 0-1.3% in August 2020 to 35-51.3%
11 in the same regions in December 2020 was noted (15). A seroprevalence study in blood donors conducted
12 in Milan between February and April 2020 during a period of intense transmission found an increase in
13 seroprevalence from 2.7% (95% 0.3-6.0%) to 5.2% (95% 2.4-9.0) , with an adjusted rate of increase in
14 antibodies (IgG) of $2.7 \pm 1.3\%$ per week as social distancing measures were gradually implemented (58).
15 While in Finland, weekly testing of blood donors from April 2020 onwards showed a consistently low
16 seroprevalence in the general population over time (0.28% (0.05–1.55) in early April 2020 to 0% (0–12.87)
17 in late December 2020 (67).

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37 The relationship between seroprevalence and reported SARS-CoV-2 laboratory confirmed cumulative case
38 and deaths incidence was also explored. While seroprevalence from national studies correlated moderately
39 with cumulative incidence (Spearman's rank correlation coefficient, 0.52) (Figure 4a), a stronger correlation
40 was observed between seroprevalence estimates and cumulative SARS-CoV-2 deaths (Spearman's rank
41 correlation coefficient, 0.754) (Figure 4b).

42 43 44 45 46 47 48 **DISCUSSION**

49 In this study we report the results of 111 studies, including 224 seroprevalence estimates from 26 countries
50 in the WHO European Region undertaken until December 2020, prior to the implementation of national
51 COVID-19 vaccine campaigns. A significant heterogeneity in implementation was noted across the studies,
52 with a bias towards studies in high-income countries in Western Europe.

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3 Overall, population-wide seroprevalence estimates were low (below 10%) across the Region early in 2020
4 before the onset of widespread community transmission and remained low across the Region throughout
5 2020, despite circulation of SARS-CoV-2 over this period. Higher estimates were observed at a regional or
6 local level in populations that had experienced intense community transmission (up to 52%). Furthermore,
7 a positive correlation between seroprevalence estimates and national cumulative incidence was observed,
8 with a stronger correlation between seroprevalence and cumulative mortality.
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18 The wide variation in seroprevalence estimates across the region are likely to reflect many factors including
19 the differences in the population studied, local stage of the epidemic and the public health and social
20 measures implemented in response to the epidemic at that time. The general low seroprevalence both at the
21 start of the pandemic and at the end of 2020 is in line with a number of global systematic review conducted
22 to date (74-76) and together indicate that the majority of the proportion of the population in the WHO
23 European Region were and remain susceptible to infection one year after the identification of SARS-CoV-2
24 and prior to the start of national vaccination campaigns. In a global systematic review, Chen et al. estimated
25 a seroprevalence of 4.2% (2.7-5.8) across the European Region until August 2020 (76) while Rostami et al.
26 estimated a pooled prevalence of 3.17% (1.96-4.38), 4.41 % (2.20-6.61), 5.27% (3.97-6.57) in Western,
27 Southern and Northern Europe, respectively (75). In the same period, Bobrovitz et al. reported a pooled
28 estimate of 1.6% (1.1-5.2%) seroprevalence in studies conducted across Central Europe, Eastern Europe
29 and Central Asia (77) and 12.2% (4.5-25.4%) from population-wide studies conducted until December 2020
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47 A number of studies reported low seroprevalence in younger and older age groups, a finding observed in
48 other systematic reviews (74, 76, 78). Such findings have important implications, as groups such as the
49 elderly are at higher risk of severe outcome following infection – and lack of cross-protective immunity
50 indicates that all age-groups will anticipate to see high infection attack rates without implementation of
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3 measures such as vaccination of priority groups, together with strengthening of public health and social
4 measures to reduce SARS-CoV-2 transmission.
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9 When reviewed alongside case notification data, seroprevalence estimates can provide greater insight into
10 the local evolution of the pandemic. In this review, a positive correlation between seroprevalence estimates
11 and national cumulative incidence in a number of countries was observed, suggesting that seroprevalence
12 is a reflection of the duration and intensity of community transmission. It should be noted however that
13 during the initial peak of infections in Europe in the spring of 2020, testing in many countries was not yet
14 optimal and case notification data at this time are unlikely to provide a robust proxy for incidence in many
15 instances. In line with this, several studies found seroprevalence estimates to be higher than the
16 corresponding cumulative incidence of SARS-CoV-2 infections, suggesting a substantial under-
17 ascertainment of infection through notifications, due to a number of factors including the asymptomatic or
18 mild nature of disease, healthcare seeking behaviour, lack of testing capacity and testing and reporting
19 strategies. Indeed, we also found a stronger association between seroprevalence and cumulative case
20 mortality than cumulative case incidence, providing further evidence to support the suggestion of case
21 under-ascertainment, as laboratory confirmed mortality surveillance for COVID-19 is likely to be more
22 comprehensive.
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41 The varying quality of studies in this review reflects the challenge of conducting seroepidemiological
42 studies of high quality. Indeed, this review found that only 50% of all studies undertaken in the WHO
43 European region in 2020 were aligned with the WHO Unity study initiative. Few of the national (n=5; 15%)
44 or regional (n=2; 7%) studies were determined to be of high risk of bias, while 17 (34%) of studies
45 conducted at a local level (cities or towns) were graded as such. This variation may be explained by the
46 level of resources and epidemiological support available to studies conducted at the regional or national
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3 The majority of studies identified in this review utilised convenience rather than random sampling, which
4 may have reduced the true representativeness of the estimates derived, though such convenience sampling
5 is likely to provide a good estimate of population exposure for widely circulating viral infections. Many
6 studies also included individuals that were not fully representative of the population under study, which
7 may have introduced bias. For example, this review included studies that explored seroprevalence in the
8 general population by utilising various proxy populations such as blood donors and residual blood. Blood
9 donors are known to differ from the general population in that they are often a young, healthy adult
10 population selected on the basis of lack of recent infection (79) and seroprevalence may therefore be over
11 or underestimated in this group. Residual sera, on the other hand, derives from individuals who have sought
12 health care and may therefore have pre-existing comorbidities or be at higher risk of SARS-CoV-2
13 infection. However, we found that seroprevalence estimates for these distinct populations are in good
14 agreement with the general population.
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30 We also found that there was a high degree of heterogeneity across serological assays used. The majority
31 of studies used commercial tests of varying sensitivity and specificity to detect SARS-CoV-2 targeted
32 antibodies, although some of these assays have now been shown to have excellent performance (80, 81).
33 However, under half of studies performed independent validation of these kits with internal controls and
34 serum panels and only 25% accounted for the sensitivity and specificity of the tests in their statistical
35 analyses. As SARS-CoV-2 serological tests have been found to have variable test performance (80, 81),
36 independent validation at local level in combination with use of an WHO International Standard and
37 Reference Panel for anti-SARS-CoV-2 antibody has been widely promoted as part of the Solidarity II
38 initiative (82, 83). Other options include the Joint Research Centre (84) reference materials for the quality
39 control of SARS-CoV-2 antibody tests. Use of these materials will allow for the potential correction for
40 sensitivity and specificity during the statistical analysis, would allow for more robust estimates and greater
41 comparability among countries in the region.
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3 Overall, the findings of this review highlight the need for international collaboration to standardise
4 approaches and support countries in conducting robust comparable studies. WHO, in collaboration with
5 technical partners, has developed the Unity studies (2)(90), a global seroepidemiology standardization
6 initiative for COVID-19, which aims to increase quality evidence-based knowledge in country and regions
7 for action through the availability of standardized seroepidemiology investigation protocols and antibody
8 assays. A primary aim of this global initiative is the provision of direct support to countries to develop
9 country specific protocols, with particular attention provided to low- and middle- income countries
10 (LMICs), and to support aggregation, comparison and analysis of robust Unity-aligned studies through
11 strong coordination between WHO Country offices, Regional offices and Headquarters. A large proportion
12 of the studies identified in this systematic review were conducted in Western European countries, with a
13 relative scarcity of seroprevalence studies from other countries by the end of 2020, an observation noted in
14 other systematic reviews (74-76, 78). This highlights the urgent need for enhanced capacity, the provision
15 of additional support to LMICs and the sharing of information to address the gap in knowledge and tackle
16 research inequity. To counteract the skewedness in the WHO European Region, the WHO Unity protocols
17 have been widely promoted by WHO and ECDC and technical support has been provided to tailor the
18 protocols to local contexts, together with laboratory and financial support to LMICs. In addition, WHO
19 and ECDC jointly established a network of approximately 300 public health professionals to facilitate
20 discussions in related to SARS-CoV-2 seroprevalence, promote timely sharing of results and knowledge
21 and further build capacity in the WHO European Region.
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45 This systematic review is the first in the WHO European region to describe the seroprevalence of SARS-
46 CoV-2 in the first year of the pandemic, prior to the widespread implementation of vaccine programs
47 nationally. In addition, with the inclusion of as yet unpublished data from LMICs, this review contributes
48 to research equity across Member States income levels and provides a more representative overview of the
49 situation in the WHO European Region than would published studies alone.
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3 This review has some limitations. Firstly, there was significant heterogeneity among the studies, including
4 sampling frame, population and stage of epidemic at time of serosurvey, which makes comparability across
5 studies difficult. Due to such heterogeneity, we opted to not provide one pooled estimate nor conduct a
6 meta-analysis, as interpretation would be difficult and may not accurately reflect the picture in the WHO
7 European Region. Secondly, while population-based serological surveys can provide a more accurate
8 estimation of the overall rates of SARS-CoV-2 infection within a population, this approach does not
9 consider antibody waning, which cannot be easily accounted for as antibody levels vary depending on
10 disease severity (85) and longevity is expected to vary greatly across SARS-CoV-2 infected individuals
11 (86). Finally, due to the rapid accumulation of data related to SARS-CoV-2 seroepidemiology and the
12 advent of the ‘preprint era’, not all included studies have been published and may therefore be subject to
13 change upon peer review.
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26 27 28 Conclusion

29 As SARS-CoV-2 continues to circulate widely, understanding the population seropositivity remains critical
30 for policymakers and public health officials to make informed decisions on optimal public health
31 interventions, such as lifting or tightening of restrictions (9, 87). We found evidence that SARS-CoV-2
32 antibody seroprevalence across the WHO European Region was low prior to widespread circulation and
33 remained low in the general population during 2020. This suggests that much of the population remained
34 susceptible to infection prior to the implementation of national COVID-19 vaccine campaigns from early
35 2021 onwards. We also found variation in seroprevalence estimates between and within countries during
36 2020 with evidence of increased prevalence in areas following high levels of transmission and some
37 association with incidence and mortality trends over time. It is clear that antibody-mediated ‘herd
38 immunity’ through natural infection is not attainable in most countries and COVID-19 vaccines should
39 continue to be distributed widely and equitably to protect priority groups and the wider population. Given
40 the issue of antibody waning, all efforts must be also directed towards well-informed and evidence-based
41 implementation and maintenance of non-pharmaceutical interventions at a local and national level to stem
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any future waves of the pandemic. As vaccine programs continue to be implemented more widely, seroprevalence studies will be instrumental to evaluate both natural and vaccine derived immunity overtime to guide public health actions and decision making.

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Data sharing

The unpublished data supporting the findings of this study are available on the open source Zenodo repository <https://zenodo.org/communities/unity-sero-2021?page=1&size=20>.

Supplementary material

Supplementary material file is attached

Registration and protocol

Not registered. A protocol was not prepared

Declaration of interests

No competing interests

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Ethics statement

This systematic review of study data did not require ethical approval. This study does not involve human participants nor animal subjects.

Authors' Contributions

Conceptualisation: AV, ED, GF, RP, MK, PP, AN, MV, IB, LS, EB; Data curation: AV, GF, ED, MK, DL; Formal analysis: AV, GF, ED, MK; Investigation: AV, GF, ED, MK, AN, MV; Methodology: AV, GF, ED, MK, AN, MV, RP, PP, EB; Supervision: AV, GF, ED, MK, RP, PP; Writing – original draft: AV, ED, GF, RP, MK, PP, IB, LS, AN, MV, EB; Writing – review & editing: All authors

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16 Figure Legend

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19 **Figure 1:** PRISMA Flow chart of SARS-CoV-2 seroprevalence study selection

20
21 **Figure 2:** Geographical distribution of SARS-CoV-2 seroprevalence studies published in the WHO
22 European Region between 1 Jan – 31 Dec 2020

23
24 **Table 1:** Study characteristics

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26 **Table 2:** Characteristics of eligible seroprevalence studies

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28 **Figure 3:** National (a) and sub-national (b) seroprevalence estimates of SARS-CoV-2 antibodies over
29 time in the WHO European Region (1/1/2020-31/12/2021)

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31 **Figure 4:** Correlation between seroprevalence point estimates from low to medium risk of bias studies
32 and cumulative (a) incidence and (b) deaths in all populations, in the WHO European Region
33 (1/1/2020-31/12/2020)

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36 **Table S1** Inclusion and exclusion criteria

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38 **Table S2:** Description of the quality assessment criteria used

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40 **Supplementary figure S1:** Forest plot of the seroprevalence of SARS-CoV-2 antibodies in
41 Community/Household samples with corresponding 95% confidence intervals in WHO European
42 Region (1/1/2020-31/12/2020)

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44 **Supplementary figure S2:** Forest plot of the seroprevalence of SARS-CoV-2 antibodies in (Top to
45 bottom, Left to Right) a) Residual sera b) Blood donors c) Pregnant or Parturient women d) Patients
46 seeking care (non-COVID) and e) Other populations

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49 **Supplementary figure S3:** Time point of conducted sero-epidemiology studies in relation to country
50 epidemic activity
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Figure 1: PRISMA Flow chart of SARS-CoV-2 seroprevalence study selection

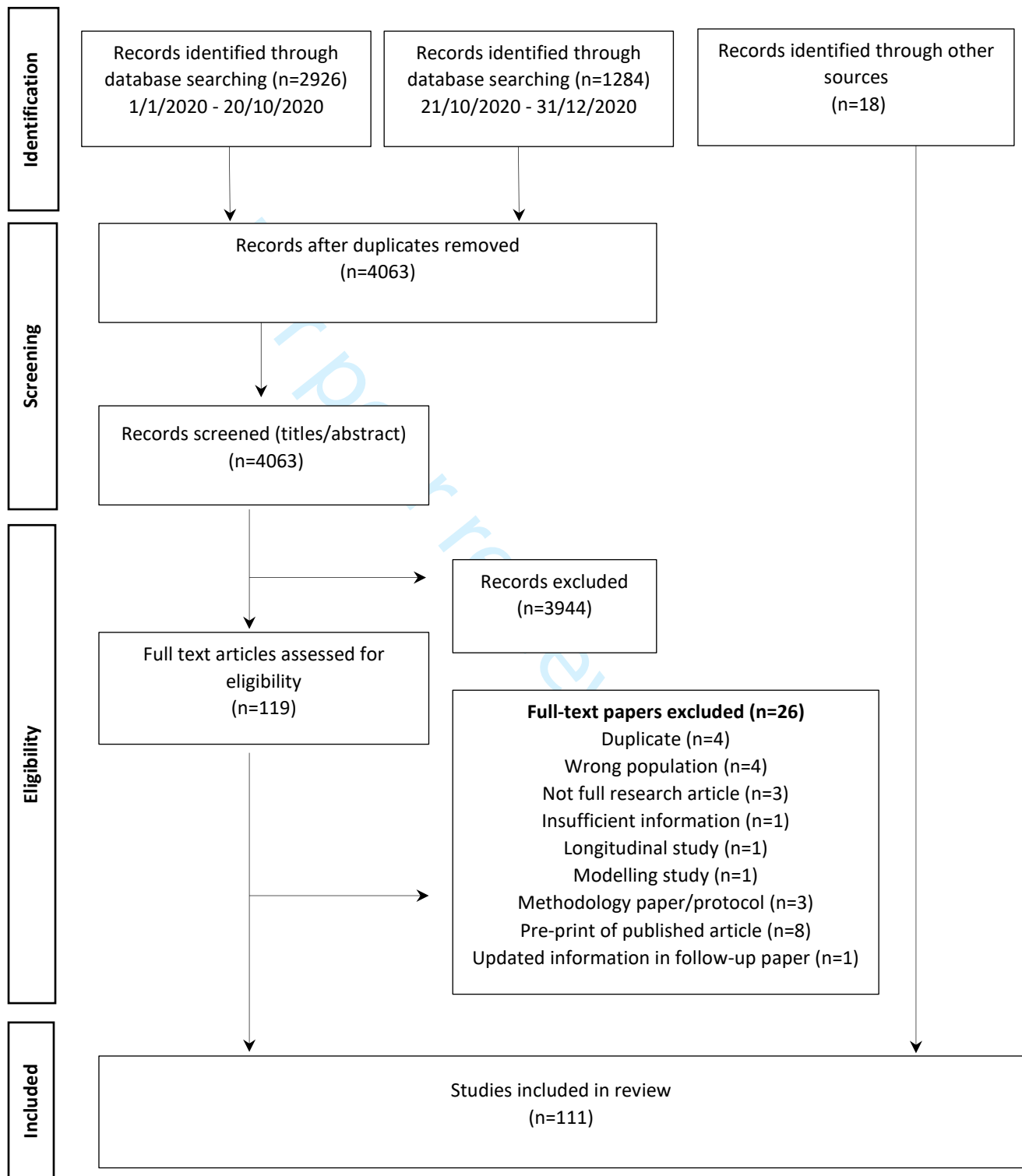
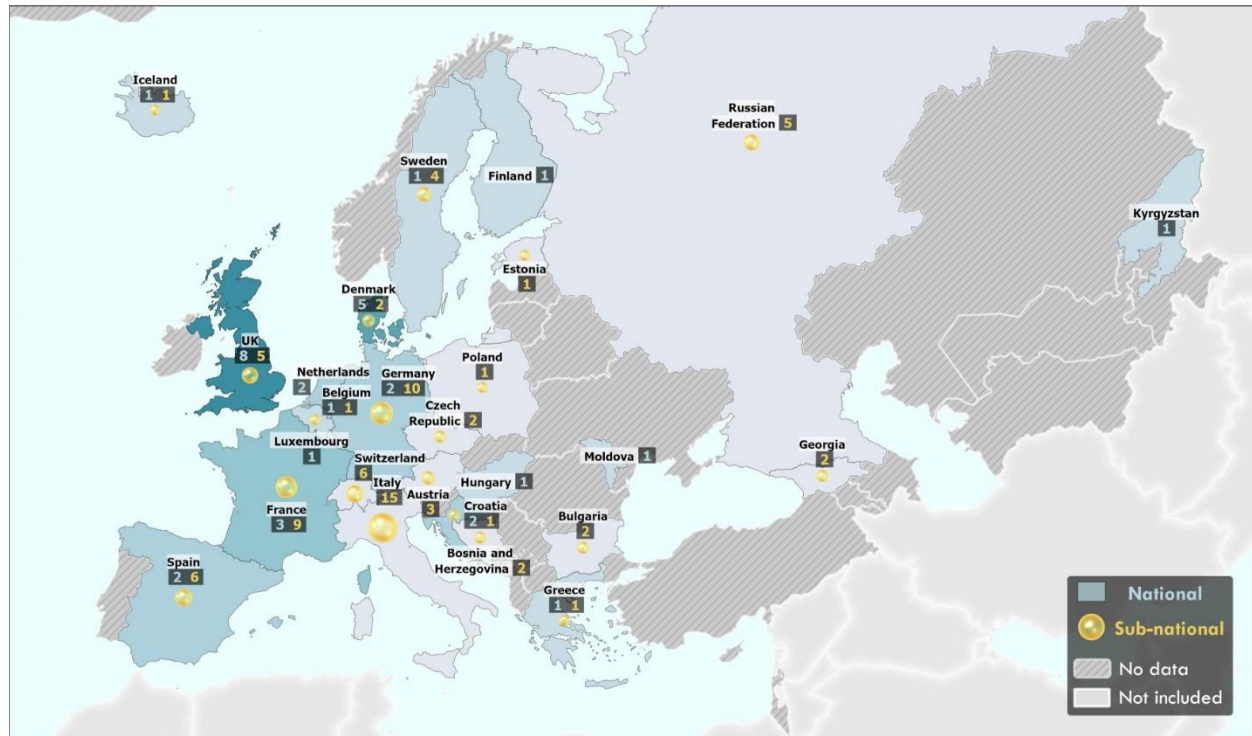


Figure 2: Geographical distribution of SARS-CoV-2 seroprevalence studies published in the WHO European Region between 1 Jan – 31 Dec 2020



Countries with national-level seroprevalence studies are reported in blue (shade of blue reflects the number of studies conducted in the country/territory). Subnational-level seroprevalence studies are reported as a yellow circle (Size of circle reflects number of subnational studies conducted in the country/territory). Number of studies are listed in boxes under name. Countries with not studies are coloured in grey. The designations employed and the presentation of this material do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dotted and dashed lines on maps represent approximate locations for which there may not yet be full agreement.

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Table 2 Characteristics of eligible seroprevalence studies

	Author	Country	Study Location	EU/non-EU	WHO UNITY aligned	Geographic location	Publication type	Study period	Study population	Sample method	Sampling frame	No of participants	Seropositivity (%)	Serologica l method	Assay	Antibody measured/ Antigen	Sensitivity (%)	Specificity (%)	Quality score	Overall risk of bias	
1																					
2	Household and community																				
3	1	Knabl (50)	Austria	Tyrol, Ischgl	EU/EEA	Yes	City/local	Published ^a	21-27 Apr	General population	Random	HH/C samples	1473	42.4% (39.8 - 44.7%)	ELISA; CLIA	EUROIMMU N; Abbott Laboratories;	Anti-S IgA; IgG; Anti-N IgG	Not reported	Not reported	8	Low
4																					
5	2	Wagner (88)	Austria	Vienna	EU/EEA	No	City/local	Pre-print	12-17 Apr	General population	Convenience	HH/C samples	1655	10.15%	ELISA; ELISA; CLIA; MN	EUROIMMU N; Beijing Wantai Biological Pharmacy Enterprise; EUROIMMU N; Roche Diagnostics; In-house;	IgA; IgG IgM and total Abs; IgG; Total Abs; NT-Abs	Not reported	Not reported	3	High
6																					
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11	3	Ladage (89)	Austria	Weißkirchen/Wachau	EU/EEA	No	City/local	Published	1-15 Jun	General population	Convenience	HH/C samples	835	ELISA: IgG 8.5%; IgA 9.0%;	ELISA;	EUROIMMU N	IgA; IgG	Not reported	Not reported	5	Medium
12																					
13	4	Boey (90)	Belgium	Pelt; Alken	EU/EEA	No	Regional	Published ^a	21 Sept - 6 Oct	General population	Random	HH/C samples	362	4.4% (low exposed - Pelt); 14.4% (high exposed - Alken)	ELISA;	Beijing Wantai Biological Pharmacy Enterprise; EUROIMMU N	Total Abs;	99.6%	Not reported	4	Medium
14																					
15																					
16																					
17	5	Bokonjic (91)	Bosnia and Herzegovina	Republika Srpska	non-EU/EEA	Yes	Regional	Not yet published	4 Nov - 16 Dec	General population	Random	HH/C samples	1855	40.4%	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	Total Abs;	94%	100%	N/A	N/A
18																					
19	6	Kunchev and Stoitsova	Bulgaria	Plovdiv	EU/EEA	Yes	City/local	Not yet published	18-May-13 Jun	General population	Random	HH/C samples	553	1.08% (0.5-2.35); 0.04% (0-0.12) ³	ELISA;	EUROIMMU N;	IgG; IgA	Not reported	Not reported	N/A	N/A
20																					
21	7	Statens Serum Institute	Denmark	Copenhagen ; Aarhus; Aalborg; Næstved; Odense	EU/EEA	Yes	National	Report	Apr	General population	Random	HH/C samples	1071	1.1% (0.5-1.8)	ELISA	Not reported	Not reported	Not reported	Not reported	6	Medium
22																					
23																					
24	8	Statens Serum Institute (92) (62)	Denmark	Copenhagen ; Aarhus; Aalborg; Næstved; Odense	EU/EEA	Yes	National	Report	7 May - 9 Jun; 14 Aug - 1 Oct	General population	Random	HH/C samples	2444; 18000	1.2 (0.7-1.7); 2.2 (1.8 - 2.6)	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	Not reported	Not reported	Not reported	9	Low
25																					
26																					
27	9	Petersen (93)	Denmark	Faroe Islands	EU/EEA	Yes	Regional	Published	27 Apr - 1 May	General population	Random	HH/C samples	1500	0.7% ³	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	IgM; IgG	94%	100%	9	Low
28																					
29																					
30	10	Jõgi (94)	Estonia	Tallinn; Saaremaa	EU/EEA	No	Regional	Pre-print	8 May - 31 Jul	General population	Random	HH/C samples	Total 1960; Tallin: 1006; Saaremaa: 954;	Tallinn: 1.5% § ; Saaremaa: 6.7% §	CMIA; CLIA; LIPS; LFA;	Abbott Laboratories DiaSorin Liaison; In-house Biosensor	IgG; IgG; NA IgM/IgG	92.7%	99.9%	12	Low
31																					
32																					
33	11	Finnish Institute for Health and Welfare – THL (14)	Finland		EU/EEA	No	National	Report	13 Apr - 28 Dec	General population	Random	HH/C samples	4863	*see report	FMIA	In-house	Not reported	Not reported	Not reported	7	Low
34																					
35																					
36																					
37	12	Carrat (95)	France	Ile-de-France; Grand Est; Nouvelle-Aquitaine;	EU/EEA	Yes	National	Pre-print	4 May - 23 Jun	General population	Random	HH/C samples	14628	Ile-de-France: 10%; Grand Est: 9.0%; Nouvelle-Aquitaine: 3.1%;	ELISA; MN	EUROIMMU N; In-house	IgG	ELISA-S=97.9%; ELISA-NP=50.3%; SN=41.4%	ELISA-S=97.7%; ELISA-NP=99.5%; SN=99.5%	9	Low
38																					
39																					
40																					
41																					
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44																					
45																					
46																					
47																					

13	Zakhashvili (15)	Georgia	Martvili; Kobuleti; Borjomi; Khelvachauri	non-EU/EEA	Yes	National	Not yet published	1 – 14 Aug 2020; 1 – 14 Dec 2020	General population	Random	HH/C samples	1218; 1219	August: 0%; 0%; 0.7%; 1.3%	ELISA; CMIA	Wantai Total Ab ELISA; Roche Diagnostics	Total Abs; Total Abs;	Not reported	Not reported	N/A	N/A	
1													December: 44.3%; 35%; 45.5%; 51.3%;								
2																					
3	14	Tsertsvadze (41)	Georgia	Tbilisi	non-EU/EEA	No	City/local	Pre-print	18-27 May	General population	Convenience	HH/C samples	1068	1.02% (0.38-2.18) §	LFA	Zhejiang Orient Gene Biotech	IgG	93.1%	99.2%	6	Medium
4	15	Aziz (96)	Germany	Bonn	EU/EEA	Yes; No	City/local	Published^	24 Apr - 30 Jun	General population	Convenience	Group 1: HH/C samples (Rhineland study); Group 2: Voluntary	Group 1: 4771; Group 2: 360;	0.97% (0.72-1.30%); 1.94% (0.84-4.42%)	ELISA	EUROIMMUN	IgG	Not reported	Not reported	7	Low
5	16	Strecek(53)	Germany	Heinsberg	EU/EEA	Yes	City/local	Published^	31 Mar - 4 Jun	General population	Random	HH/C samples	919	14.1% (11.15% - 17.27%) §	ELISA	EUROIMMUN;	IgA; IgG	90.9%	99.1%	10	Low
6	17	Santos-Hövenner (54)	Germany	Kupferzell	EU/EEA	Yes	City/local	Published	20 May - 9 Jun	General population	Random	HH/C samples	2203	12% (10.4-14%) §	ELISA	EUROIMMUN	IgG	88.3%	99.2%	10	Low
7	18	Weis (97)	Germany	Thuringia	EU/EEA	No	Regional	Published	12-22 May	General population	Random	HH/C samples	626	8.4%	ELISA; ELISA; CLIA; CMIA; CLIA; CLIA	EUROIMMUN; Epitope Diagnostics Inc. DiaSorin Abbott Laboratories Roche Diagnostics Snibe Co.	IgG	Not reported	Not reported	10	Low
8	19	Merkely (98)	Hungary		EU/EEA	Yes	National	Published	1-16 May	General population	Random	HH/C samples	10474	0.68 (0.5-0.86)	CMIA	Abbott Laboratories	IgG	Not reported	Not reported	6	Medium
9	20	Pagani (43)	Italy	Castiglione D'Adda	EU/EEA	Yes	City/local	Published	18 May - 7 Jun	General population	Random	HH/C samples	509	22.6% (17.2-29.1)	CMIA; LFA	Abbott Laboratories ; Prima Lab	IgG	Not reported	Not reported	9	Low
10	21	Stefanelli (36)	Italy	Trento	EU/EEA	Yes	Regional	Published	5-15 May	General population	Random	HH/C samples	6075	25.7% §	CMIA	Abbott Laboratories	IgG	99.60%	100%	10	Low
11	22	Guerrero (99)	Italy	Verona	EU/EEA	Yes	City/local	Published	24 Apr - 8 May	General population	Random	HH/C samples	1515	2.6%	CMIA	Abbott Laboratories	IgG	81.80%	99.30%	8	Low
12	23	Cito (100)	Italy	Villa Caldari, Abruzzo region	EU/EEA	Yes	Regional	Published	18-19 Apr	General population	Random	HH/C samples	687	10.9% (8.8-13.5%)	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	Total Abs	93%	100%	9	Low
13	24	Zuridin & Tatyana (34)	Kyrgyzstan	Bishkek City; Osh City; Chui; Osh; Jalal-Abad; Batken; Issyk-Kul; Naryn; Talas	non-EU/EEA	Yes	National	Not yet published	4 Jul – 12 Aug	General population	Random	HH/C samples	4780	32.5%	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	Total Abs	95%	100%	N/A	N/A
14	25	Snoeck (101)	Luxembourg		EU/EEA	Yes	National	Pre-print	15 Apr - 5 May	General population	Random	HH/C samples	1862	IgG: 2.09% (1.37-2.82) § IgA: 11.07% (9.54-12.60) §	ELISA	EUROIMMUN;	IgG; IgA;	85.7%; 92.2%;	97.8%; 89.2%; 1	8	Low
15	26	Vos (33)	Netherlands		EU/EEA	No	National	Published	31 Mar - 11 May	General Population	Random	HH/C samples	3207	2.8% (2.1 - 3.7) §	Fluorescent bead-based multiplex immunoassay	In-house	IgG	84.40%	Not reported	10	Low
16	27	Popova (102)	Russian Federation	Irkutsk Region	non-EU/EEA	No	Regional	Published	28 Jun - 19 Jul	General population	Random	HH/C samples	2674	5.8% (5.3- 6.2)	ELISA	In house	IgG	Not reported	Not reported	8	Low
17	28	Popova (103)	Russian Federation	Leningrad	non-EU/EEA	No	Regional	Published	23 Jun - 26 Jun	General population	Random	HH/C samples	3130	20.70%	ELISA	In house	IgG	Not reported	Not reported	8	Low
18	29	Barchuk (37)	Russian Federation	Saint-Petersburg	non-EU/EEA	Yes	City/local	Published^	27 May - 26 Jun	General population	Random	HH/C samples	1038	9.0% CMIA; 10.8% ELISA §	ELISA; CMIA	CoronaPass; Abbott Laboratories	IgG; Total Abs	98.7%; 100%	100%; 99.6%	12	Low
19	30	Popova (104)	Russian Federation	Saint-Petersburg	non-EU/EEA	No	City/local	Published	15 Jun - 20 Jun	General population	Random	HH/C samples	2713	26% (24.3-27.7)	ELISA	In house	IgG	Not reported	Not reported	8	Low

Page	Ref	Author	Country	Region	EU/EEA	Yes/No	Study Type	Date	Population	Design	Sample Type	n	Prevalence	Method	Setting	Antibody	Sensitivity	Specificity	PPV	NPV	LR+	LR-	Conclusion
31	Pogorza (49)	Russian Federation	Tyumen region	non-EU/EEA	No	Regional	Published	8 - 21 Jun	General population	Random	HH/C samples	2758	24.5% (22.9- 26.1)	ELISA	In house	IgG	Not reported	Not reported	8			Low	
32	Pollan (105)	Spain		EU/EEA	Yes	National	Published	27 Apr - 11 Ma	General population	Random	HH/C samples	51958	4-6% (4-3-5-0) ¹	CLIA; LFA;	Abbott Laboratories; Zhejiang Orient Gene Biotech	IgG	89.7%	100%	12			Low	
33	Public Health Agency of Sweden (106)	Sweden	Rinkeby-Kista district, Stockholm	EU/EEA	Yes	City/local	Report	22 Jun - 24 Jun	General population	Random	HH/C samples	538	18.7% (95% CI 14.8-23.3)	CMIA; CLIA; LIPS; LFA;	Abbott Laboratories; DiaSorin Liaison	IgG	100	99.6	11			Low	
34	Roxhed (57)	Sweden	Stockholm	EU/EEA	Yes	City/local	Published [^]	mid-Apr - mid-May	General population	Random	HH/C samples	878	12.5% (95% CI: 10.3%-14.7%)	ELISA	In house	IgM; IgG	100%	98%	7			Low	
35	Richard (38)	Switzerland	Canton of Geneva	non-EU/EEA	Yes	Regional	Pre-print	6 Apr - 30 Jun	General population	Random	HH/C samples	8344	7.8% (6.8-8.9)	ELISA	EUROIMMUN	IgG	93%	100%	10			Low	
36	Bi (107)	Switzerland	Geneva	non-EU/EEA	Yes	City/local	Pre-print	3 Apr - 30 Jun	General population	Random	HH/C samples	4354	6.6%	ELISA	EUROIMMUN	IgG	93%	99%	9			Low	
37	Stringhini (32)	Switzerland	Geneva	non-EU/EEA	Yes	City/local	Published	6 April - 9 May	General population	Random	HH/C samples	2766	1st week: 4-8% (2.4-8.0); 2nd week: 8-5% (5.9-11.4); 3rd week: 10-9% (7.9-14.4); 4th week: 6-6% (4.3-9.4); 5th week: 10-8% (8.2-13.9)	ELISA	EUROIMMUN	IgG	93%	100%	9		Low		
38	Ward (47)	United Kingdom	England	non-EU/EEA	No	National	Pre-print	20 Jun - 13 Jul; 31 Jul - 13 Aug; 15 Sept - 28 Sept	General population	Random	HH/C samples	99908; 105829; 159367	5.9% (5.78-6.14); 4.83 (4.67-5.00); 4.38 (4.25-4.51) ¹	LFA	Fortress Diagnostics	IgG	84.4%	98.6%	9			Low	
39	Wells (108)	United Kingdom	London; South East England	non-EU/EEA	Yes	Regional	Published	27 Apr - 2 Jun	General population	Convenience	HH/C samples	431	12% (9.1-15.2)	CLIA; CMIA	Abbott Laboratories; Roche Diagnostics	IgM; IgG	90%	100%	6			Medium	
Residual sera																							
40	Herzog (56)	Belgium	Wallonia Flanders; Brussels	EU/EEA	Yes	National	Pre-print	30 Mar - 5 Apr; 20 Apr - 26 Apr; 18 May - 25 May; 8 Jun - 13 Jun; 29 Jun - 4 Jul	General population	Convenience	Residual sera	Total: 15529; 3910; 3397; 3242; 2960; 3023;	2.9% (2.3-3.6%); 6.0% (5.1-7.1%); 6.9% (5.9-8.0%); 5.5% (4.7-6.5%); 4.5% (3.7-5.4%)	ELISA	EUROIMMUN;	IgG	64.5 - 87.8%	99.20%	5			Medium	
41	Tsaneva-Damyanova (109)	Bulgaria	Varna city; North East Bulgaria	EU/EEA	Yes	Regional	Published	26 Mar - 20 Apr	General population	Convenience	Residual sera	586	4.8% overall; 1.0% IgM, 1.2% IgG 2.6% IgM and IgG	LFA	Zhejiang Orient Gene Biotech	IgM; IgG	85%	96%	4			Medium	
42	Bloomfield (110)	Czech Republic	Prague	EU/EEA	Yes	City/local	Published	3 Jul - 19 Aug	General population	Convenience	Residual sera (Children)	200	0% (0-0.5%)	ELISA; CLIA	EUROIMMUN; Roche Diagnostics	IgA; IgG	EUROIMMUN: IgA=98.6%; IgG=94.4%; Elecsys=99.5%;	EUROIMMUN: IgA=92.6%; IgG=99.6%; Elecsys=99.8%;	3			High	
43	Krlezja (65)	Croatia	Zagreb	EU/EEA	No	National	Published [^]	13 - 29 May; 24 Oct - 23 Nov	General population	Convenience	Residual sera (Children)	240; 308	2.9%; 8.4%	ELISA; CLIA; MN	Vircell; Roche Cobas Elecsys; In-house	Not reported	Not reported	Not reported	3			High	
44	Capai (111)	France	Corsica	EU/EEA	Yes	Regional	Published	16 Apr - 15 Jun	General population	Convenience	Residual sera	1973	5.5% (4.5-6.6%) [§]	ELISA; MN	EUROIMMUN; In-house	IgG	Not reported	Not reported	8			Low	
45	Cohen (112)	France		EU/EEA	Yes	City/local	Pre-print	14 Apr - 12 May	General population	Convenience	Residual sera (Children)	605	10.7% (8.4-13.5)	LFA	Biosynex BSS test	IgM; IgG	91.8%	99.2%	5			Medium	
46	Le Vu (61)	France		EU/EEA	Yes	National	Published [^]	9 Mar - 15 Mar; 6 Apr - 12 Apr; 11 May - 17 May;	General population	Convenience	Residual sera	Total: 11 021; 3834; 3595; 3592;	March:0.41% [0.05-0.88] [§] ; April: 4.14% [3.31-4.99] [§] ; May: 4.93% [4.02-5.89] [§]	LuLISA; MN	In-house; In-house;	IgG; NT-Abs	LuLISA N=86%; LuLISA S=96%	LuLISA N=100%; LuLISA S=100%	13			Low	

Study ID	Author(s)	Country	Region	EU/EEA	Yes/No	National/Regional/City/local	Published/Report	Date	Population	Convenience	Residual sera	Sample Size	Prevalence	Method	Lab	Serology	Prevalence	Prevalence	Number	Quality
47	Bogogiannidou (113)	Greece		EU/EEA	Yes	National	Published	1 Mar - 30 Apr	General population	Convenience	Residual sera	6586	March = 0 (0.0-23%) [‡] ; April=0.23% (0-0.48%) [‡]	ELISA; ELISA; CMIA	EUROIMMUN; Vircell; Abbott Laboratories	IgG	84%	99.7%	8	Low
48	Gudbjartsson (13)	Iceland		EU/EEA	Yes	Regional; National	Published	18 Feb - 9 Mar	General population	Convenience	Residual sera	470; 24115	0%; Residual sera: 0.30% (0.2 - 0.4) §; Reykjavik: 0.4% (0.3 - 0.6)	ELISA; ELISA; CLIA	EUROIMMUN; EDI/Eagle; Roche Diagnostics	IgA; IgM; IgG	Not reported	99.80%	9	Low
49	Public Health Agency of Sweden (65, 66)	Sweden	Jämtland Härjedalen, Jönköping, Kalmar, Skåne, Stockholm, Uppsala, Västerbotten, Västra Götaland and Örebro	EU/EEA	No	National	Report	20 Apr to 12 Jun; 12 Oct to 23 Oct; Nov 23 to 4 Dec	General population	Convenience	Residual sera	4500 per collection period	20 April-26 April: 5.3% (3.8-7.1); 27 April-3 May: 4% (2.71-5.67); 4 May - 10 May: 3.9% (2.61-5.42); 11-17 May: 4.5% (3.07-6.15); 18-24 May: 5.2% (3.67-7); 25-31 May: 5.7% (3.98-7.72); 1-7 June: 6.8% (5.07-8.80); 8-14 June: 5.2% (3.74-7.06); 12-23 October: 6.7% (5.67-7.79); 23 November to 4 December: 7.9% (6.79-9.19);	Not reported	Sci Life Lab / KTH	Not reported	98.9	99.4	6	Low
50	Posfay-Barbe (114)	Switzerland	Geneva	non-EU/EEA	No	City/local	Published	1-30 Apr	General population	Convenience	Residual sera	208	ELISA: 9.1%; LFA: 12.5%	ELISA; LFA	EUROIMMUN	IgG	Not reported; 88.9%	Not reported; 94.7%	2	High
51	Dickson (115)	United Kingdom	Scotland	non-EU/EEA	Yes	National	Published	20 Apr - 15 Jun	General population	Convenience	Residual sera	4751	4.3% (4.2-4.5)	CLIA	DiaSorin Liaison	IgG	87.5%	98.6%	3	High
52	Public Health Scotland (64)	United Kingdom	Scotland	EU/EEA	Yes	National	Report	20 Apr - 17 May; 18 May - 14 Jun; 15 Jun - 12 Jul; 13 Jul - 9 Aug;	General population	Convenience	Residual sera	2039; 2172; 2709; 2882	4.1% (2.4%, 5.7%); 3.4% (1.8%, 5.0%); 3.9% (2.3%, 5.4%); 3.7% (2.2%, 5.2%)	CMIA	DiaSorin Liaison	Not reported	Not reported	Not reported	4	Medium
Blood donors																				
53	Musa (40)	Bosnia and Herzegovina	Federation of Bosnia and Herzegovina	non-EU/EEA	Yes	Regional	Not yet published	1 Nov - 7 Dec	Blood donors	Convenience	Blood donors	1015	19.1% (16.7-21.5)	CMIA	Abbott Laboratories	Total Abs;	Not reported	Not reported	N/A	N/A
54	Pedersen (35)	Denmark	Danish Capital Region; Zealand Region; Central Denmark Region	EU/EEA	Yes	National	Published	2 Jun - 19 Jun	Blood donors	Convenience	Blood donors	Total: 2311; 17-69yrs: 1110; >70yrs: 1201	17-69yrs: 2.5 (1.3-3.8) [‡] >70yrs: 1.4 (0.3-2.5) [‡]	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	Total Abs;	96.7% (92.4-98.6)	99.5% (98.7-99.8)	7	Low
55	Erikstrup (116)	Denmark		EU/EEA	Yes	National	Published [^]	6 Apr - 3 May	Blood donors	Random	Blood donors	20 640	2.0% (95% CI, 1.8-2.2%); 1.9% (95% CI, 1.8-2.3) [‡]	LFA	Livzon Diagnostics Inc	IgM; IgG	82.6%	99.5%	7	Low
56	Bloddonor (117)	Denmark		EU/EEA	No	National	Report	5 Oct - 31 Dec	Blood donors	Convenience	Blood donors	71883	October : 2.1% (1.1-2.7); October : 1.9% (0.9-2.5); October : 2.3% (1.3-2.8); October : 2.1% (1.1-2.7); November : 2.2% (1.2-2.7); November : 2.7% (1.6-3.2); November : 2.8% (1.7-3.4); November : 3.2% (2.1-3.8); December : 3.2% (2.2-3.9);	LFA	Livzon	Not reported	Not reported	Not reported	4	Medium

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
57	Gallian (46)	France	Haut-Rhin departement l area [DA]; Seine- Saint-Denis DA; Bouches- du-Rhône DA; Oise DA; Lille	EU/ EEA	No	National	Published	23 Mar - 5 Apr	Blood donors	Convenience	Blood donors	998	2.71%	MN	In-house	NT-Abs	Not reported	100%	6	Mediu m																										
58	Grzelak (118)	France		EU/ EEA	No	City/local	Published	20-24 Mar	Blood donors	Convenience	Blood donors	200	3%	ELISA; LIPS; MN	In-house; In-house; In-house;	IgA; IgG; IgM	Not reported	Not reported	3	High																										
59	Fischer (119)	Germany	Hesse; Lower Saxony; North Rhine- Westphalia Southwest	EU/ EEA	Yes	National	Published	Mar - Jun	Blood donors	Convenience	Blood donors	3186	0.91% (0.58-1.24)	ELISA; CLIA; CMIA	EUROIMMU N; Diasorin Liaison; Abbott Laboratories Epitope	IgG	65%	99-100%	4	Mediu m																										
60	Runkel (17)	Germany		EU/ EEA	Yes	Regional	Published	Mar - Jun	Blood donors	Convenience	Blood donors	3754	0.40%	ELISA; ELISA; CLIA; CMIA	Diagnosics; IDK5000 Immundiagno stik AG; Abbott Architect; Roche Diagnosics In-house	IgG	Not reported	Abbott=99.6 %; IDK5000=9 9.1%; EDI=96.4%	7	Low																										
61	Percivalle (120)	Italy	Lombardy	EU/ EEA	Yes	City/local	Published	18 Mar - 6 Apr	Blood donors	Convenience	Blood donors	390	23%	MN		NT-Abs	95%	100%	6	Mediu m																										
62	Fiore (44)	Italy	South East	EU/ EEA	No	Regional	Published	1-31 May	Blood donors	Convenience	Blood donors	904	0.99%	CLIA	Snibe Co., Ltd.	IgM; IgG	IgM=78.65%; IgG=91.21%	IgM=97.5% ; IgG=97.3% 99.20%	4	Mediu m																										
63	Valenti (58)	Italy	Milan	EU/ EEA	Yes	City/local	Pre-print	24 Feb - 8 Apr	Blood donors	Convenience	Blood donors	789	February/March: 2.7% (95% 0.3-6.0%); March/April: 5.2% (2.4-9.0)§	LFA	Prima Lab	IgM; IgG	IgM=68%; IgG=100%	10	Low																											
64	Slot (48)	Netherlands		EU/ EEA	Yes	National	Published	1-15 Apr	Blood donors	Convenience	Blood donors	7361	3.40%	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	IgA; IgM; IgG	100%	99.1-100%	5	Mediu m																										
65	Lundkvist (18)	Sweden	Djurgårdsst aden and Tensta (Stockholm)	EU/ EEA	Yes	City/local	Published	17-18 Jun	Blood donors	Random	Blood donors	213	Djurgårdsstaden: 4.1% (0.6-7.6%); Tensta: 30.0% (20.3- 39.7%)	LFA	Zhejiang Orient Gene Biotech	IgM;IgG	IgM=100%; IgG=100%	IgM=100%; IgG=95.5%	6	Mediu m																										
66	Public Health England (67- 72)	United Kingdom	England	non- EU/ EEA	Yes	National	Report	23 Mar - 3 Dec	Blood donors	Convenience	Blood donors	1000 samples/week/ region	6 May - 29 May: 8.3 (7.5- 9.2) 4 June - 29 June: 7.6 (6.9- 8.4) 29 June - 28 July: 5.9 (5.3- 6.5) 20 July - 16 August: 5.5 (4.9-6.1); 13 August - 6 September: 5.8 (5.1-6.4); 24 August - 18 September: 6.1 (5.4 - 6.8); 21 October - 13 November: 6.0% (5.4 - 6.6); 16 November- 13 December: 6.9% (6.3 - 7.6) [§]	ELISA	EUROIMMU N	IgG	79%	99%	4	Mediu m																										
67	Thompson (121)	United Kingdom	Scotland	non- EU/ EEA	Yes	National	Published	17 Mar - 18 May	Blood donors	Convenience	Blood donors	3500	3.17%	CLIA; CMIA	Abbott Laboratories;	IgM; IgG	94.1%	100%	8	Low																										

68	Public Health Scotland (64)	United Kingdom	Scotland	EU/EEA	Yes	National	Report	29 Jun - 9 Aug	Blood donors	Convenience	Blood donors	3220	3.1% (2.5%, 3.8%)	Not reported	Not reported	Not reported	Not reported	5	Medium		
1	Patients seeking healthcare (non-COVID-19)																				
2	69	Fogel (122)	France	Paris	EU/EEA	No	City/local	Published	1 Jun - 31 Aug	General population	Convenience	Patients seeking care (non-COVID-19)	249	2.8%	CMIA	Abbott Laboratories	IgG	Not reported	Not reported	2	High
3	70	Choi (123)	Germany	Berlin	EU/EEA	No	City/local	Published	19 Mar - 19 May	General population	Convenience	Patients seeking care (non-COVID-19)	223	7.20%	ELISA; IFIT; PRNT	EUROIMMUN; In house; In house	IgA; IgG	Not reported	Not reported	1	High
4	71	Rauber (124)	Germany	Heidelberg	EU/EEA	No	City/local	Published	5 May - 8 Jun	General population	Convenience	Patients seeking care (non-COVID-19)	219	3.2%	ELISA	EUROIMMUN	IgG	94.6%	99.8%	1	High
5	72	Zambelli (29)	Italy	Bergamo	EU/EEA	No	City/local	Published	1-30 Apr	General population	Convenience	Patients seeking care (non-COVID-19)	560	31%	LFA	Moers	IgM; IgG	Not reported	Not reported	2	High
6	73	Medas (125)	Italy	Cagliari	EU/EEA	No	City/local	Published	31 Mar - 30 Jun	General population	Convenience	Patients seeking care (non-COVID-19)	86	5.8%	CLIA	Snibe Co., Ltd	IgM; IgG	Not reported	Not reported	1	High
7	74	Capasso (126)	Italy	Campania Region	EU/EEA	No	Regional	Published	11 May - 15 Jun	General population	Convenience	Patients seeking care (non-COVID-19)	310	2.90%	LFA	Shanghai Kehua LFAI	IgM; IgG	66%	96.60%	4	Medium
8	75	Cento (127)	Italy	Milan	EU/EEA	No	City/local	Published	11 May - 5 Jul	General population	Convenience	Patients seeking care (non-COVID-19)	2753	5.1% (4.3%-6.0%)	CLIA; CLIA	Abbott Laboratories DiaSorin Liaison	IgG	84.2-100%	99.6-100%	4	Medium
9	76	Berte (128)	Italy; Germany	Milan and Cagliari; Erlangen	EU/EEA	No	Regional	Published	Apr - Jun	General population	Convenience	Patients seeking care (non-COVID-19)	354; Milan, Italy: 129; Cagliari, Italy: 48; Erlangen, Germany: 177	2.3% (0.8- 3.8)	ELISA	In house	IgA; IgG	IgA=71.4%; IgG=97.64%	IgA=99.8%; IgG=95.2%	4	Medium
10	77	Vena (45)	Italy	Liguria; Lombardia	EU/EEA	No	Regional	Published	Mar - Apr	General population	Convenience	Patients seeking care (non-COVID-19)	3609	11% (10.0-12.1)	CLIA; LFA; LFA	MaglumiTM; Realy tech; Biosynex BSS	IgM; IgG	IgM=78.6-100%; IgG=90.6-100%	IgM=88.7-97.5%; IgG=90.6-100%	4	Medium
11	78	Cabezón-Gutiérrez (30)	Spain	Madrid	EU/EEA	No	City/local	Published	29 May - 19 Jun	General population	Convenience	Patients seeking care (non-COVID-19)	229	31.40%	LFA	Hangzhou Testsea Biotechnology	IgM; IgG	IgM=88%; IgG=96%	IgM=100%; IgG=100%	4	Medium
12	79	Prados (129)	Spain		EU/EEA	No	National	Published	27 Apr - 26 Jun	General population	Convenience	Patients seeking care (non-COVID-19)	6140	0.70%	ELISA	EDI Epitope Diagnostics	IgM; IgG	Not reported	Not reported	3	High
13	80	Clarke (28)	United Kingdom	London	non-EU/EEA	No	City/local	Published	27 Apr - 7 May	General population	Convenience	Patients seeking care (non-COVID-19)	356	36.2%	CMIA	Abbott Laboratories	IgG	Not reported	Not reported	3	High
14	81	Prendecki (130)	United Kingdom	London	non-EU/EEA	No	City/local	Published	1-30 Jun	General population	Convenience	Patients seeking care (non-COVID-19)	855	8.1% (95% CI 6.4 to 10.1); 10.4% (8.5 - 12.6%) CMIA + LFA results	CMIA; LFA	Abbott Laboratories; Fortress Diagnostics	IgG	90.6%; 96.5%	Not reported	4	Medium
15	Pregnant or parturient women																				
16	82	Egerup (19)	Denmark	Copenhagen	EU/EEA	No	City/local	Published	4 Apr - 3 Jul	General population	Convenience	Pregnant or parturient women; Partners; Newborns	Total: 3707; Pregnant or parturient women: 1313 Partners: 1188; Newborns: 1206	Pregnant or parturient women: 2.6% (1.7-4.0) [§] Partners: 3.5% (2.3 - 5.1) [§] Newborns: 1.4% [§]	CLIA	Shenzhen Yhlo Biotech	IgM; IgG	IgM=42%; IgG=94%	IgM=99.7%; IgG=99.3%	7	Low
17	83	Mattern (20)	France	Paris	EU/EEA	Yes	City/local	Published	4-31 May	General population	Convenience	Pregnant or parturient women	249	8%	CMIA	Abbott Laboratories	IgG	Not reported	Not reported	3	High
18	84	Tsatsaris (21)	France	Paris	EU/EEA	Yes	City/local	Published	29 Apr - 26 Jun	General population	Convenience	Pregnant or parturient women	529	4.7% (3.0-6.7%)	CMIA	Abbott Laboratories	IgG	92.7 - 97.3 %	>99%	3	High
19	85	Cosma (22)	Italy	Turin4/6/20 20	EU/EEA	No	City/local	Published	16 Apr - 4 Jun	General population	Convenience	Pregnant or parturient women	138	5.80%	CLIA; LFA; LFA	DiaSorin Liaison; Boditech; AFIAS	IgM; IgG	Not reported	Not reported	2	High
20	86	Crovetto (23)	Spain	Madrid	EU/EEA	Yes	City/local	Pre-print	14 Apr - 5 May	General population	Convenience	Pregnant or parturient women	874	14.3%	CLIA	Vircell	IgA; IgM; IgG	IgM/IgA=89 %; IgG=70%	IgM/IgA=99 %; IgG=89%	2	High
21	87	Villalain(24)	Spain	Madrid	EU/EEA	No	City/local	Published	28 Feb - 10 May	General population	Convenience	Pregnant or parturient women	769	11.2%	ELISA	In house	IgG	Not reported	Not reported	2	High

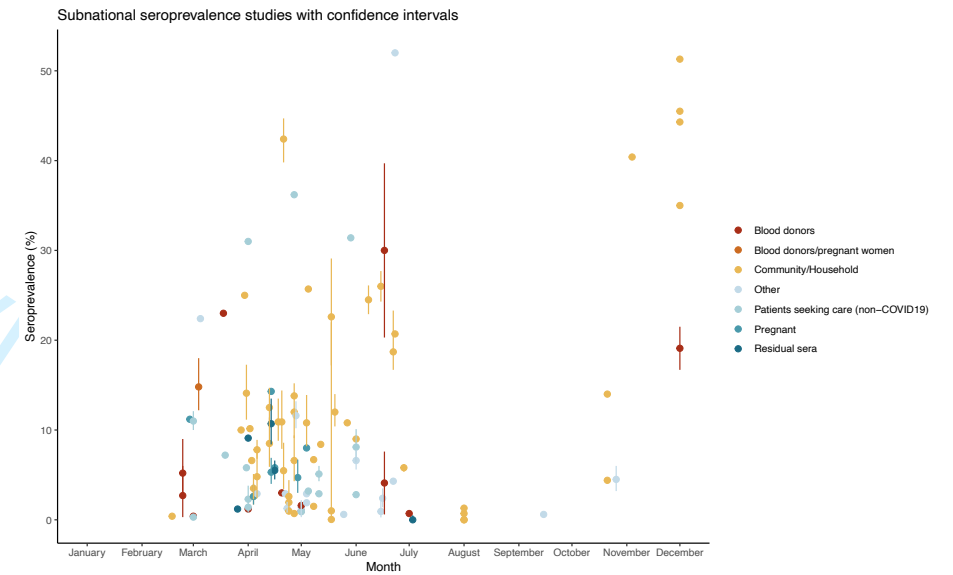
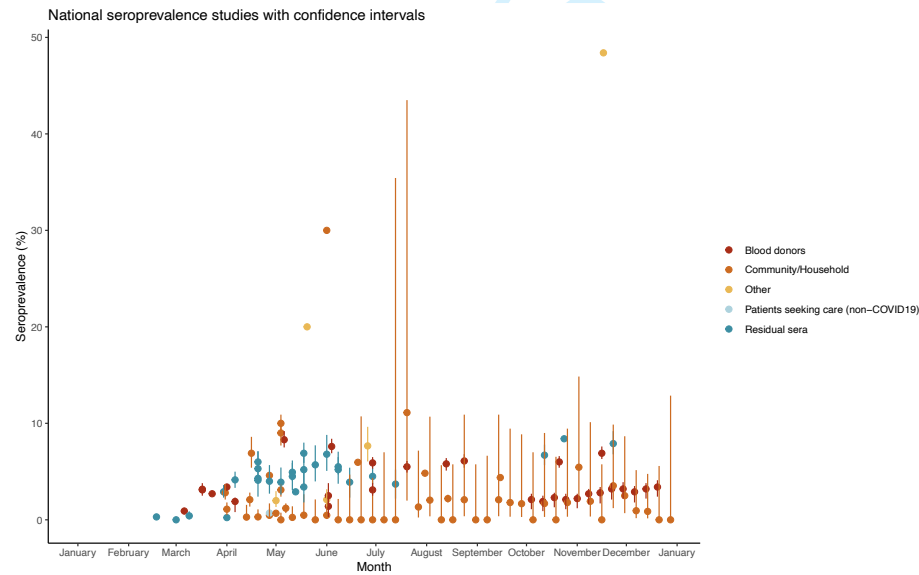
88	Lumley (425)	United Kingdom	Oxford	non-EU/EEA	Yes	City/local	Published	14 Apr - 15 Jun	General population	Convenience	Pregnant or partner with women	1000	5.3% (4.0-6.9)	CLIA	In house	IgG	99.1%	99%	4	Medium	
Other/Multiple populations																					
1	89	Kráták (131)	Czech Republic	Stratonic; Pisek	EU/EEA	No	Regional	Published	4-15 May	Other	Not reported	Employees	2011	Stratonic 2.9%; Pisek 1.9%	ELISA	EUROIMMUN	IgA; IgG	IgA=98.6%; IgG=94.4%	IgA=92%; IgG=99.6%	5	Medium
2																					
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4	90	Jerkovic (132)	Croatia	Split-Dalmatia; Sibenik-Knin County	EU/EEA	No	Regional	Published	23-28 Apr	Other	Convenience	Employees - voluntary	1494	1.27% (0.8-2.0%)	LFA	AMP Diagnostics	IgM; IgG	IgM=95.7%; IgG: 91.8%	IgM=97.3%; IgG=96.4%	6	Medium
5																					
6																					
7	91	Vince (51)	Croatia		EU/EEA	No	National	Pre-print	20 May - 31 Jul	Other	Convenience	Football players	305	20%	ELISA	EUROIMMUN	IgA; IgG	Not reported	Not reported	2	High
8	92	Anna (133)	France	Ile-de-France; Paris; Saint-Cloud; Orsay	EU/EEA	No	City/local	Published	28 Apr - 31 Jul	Other	Convenience	Employees - voluntary	1847	11.6%	LuLISA; MN	In-house; In-house	IgG	Not reported	98%	6	Medium
9																					
10																					
11	93	Fontanet (52)	France	Oise	EU/EEA	No	City/local	Published^	30 Mar - 4Apr; 28 Mar - 30 Apr	Other	Convenience	HH/C samples; High school; Primary school	664 1340	25%; 10%	ELISA; S-flow LIPS;	In-house; In-house; In-house	IgG	99.4%	>99%	8	Low
12																					
13	94	Roederer (16)	France	Paris	EU/EEA	No	City/local	Published^	23 Jun - 2 Jul	Other	Convenience	Persons experiencing homelessness	818	52%	LuLISA* ; MN	In-house	IgG	Not reported	97-100%	9	Low
14																					
15	95	Krähling (134)	Germany	Frankfurt am Main	EU/EEA	No	City/local	Pre-print	6-14 Apr	Other	Convenience	Employees	998	2.90%	ELISA	In-house	IgG	87.2-100%	99.2%	4	Medium
16	96	Mack (60)	Germany		EU/EEA	No	National	Published	May; June	Other	Convenience	Professional football teams	1184	May: 1.99% (1.33-2.97); June: 2.09% (1.37-3.17);	ELISA; CLIA	EUROIMMUN; Roche Diagnostics	IgG	Not reported	Not reported	3	High
17																					
18	97	Ceban (135)	Republic of Moldova		non EU/EEA	Yes	National	Not yet published	17 Nov 2020 - 15 Jan 2021	Other	Random	Hospital visitors	5656	48.4%	ELISA	Beijing Wantai Biological Pharmacy Enterprise	Total Ab	Not reported	Not reported	N/A	N/A
19																					
20																					
21	98	Gujski (136)	Poland	Mazowieckie Province	EU/EEA	No	Regional	Published	22 Jun - 8 Jul	Other	Random	Employees	5082	4.30%	ELISA	Vircell	IgA; IgM; IgG	65% - 97%	82% - 96%	3	High
22	99	Pérez-García (55)	Spain	Madrid	EU/EEA	No	City/local	Published	5 Mar - 30 May	Other	Convenience	Employees	2963	22.40%	LFA	AllTest Biotech	IgM; IgG	88%	100%	4	Medium
23																					
24	100	Ulyte (73)	Switzerland	Canton of Zurich	non-EU/EEA	No	Regional	Published^	16 Jun - 9 Jul; 26 Oct - 19 Nov	Other	Random	School children	5155; 2603; 2552	7.8% (6.2% to 9.5%); 2.4% (1.4-3.5); 4.5% (3.2-6.0);	ELISA	In-house	IgA; IgM; IgG	93.3-94.3%	99-99.6%	6	Medium
25																					
26	101	Roarty (137)	United Kingdom	Belfast; Cardiff; Glasgow; London; Manchester	non-EU/EEA	No	National	Published	26 Jun - 15 Aug	Other	Convenience	Children of employees	849	7.66% (6.05-9.64)	CLIA; CLIA	Elecsys Roche; DiaSorin Liaison	IgG	84%; 64%	100%; 98%	4	Medium
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30	102	Waterfield (138)	United Kingdom	Belfast; London; Glasgow; Manchester; Cardiff	non-EU/EEA	No	National	Published	16 Apr - 3 Jul	Other	Convenience	Children of employees	992	6.9% (5.4 - 8.6)	CLIA; CMIA	Abbott Laboratories; Roche Diagnostics; DiaSorin Liaison	IgG	64-94%	98-100%	4	Medium
31																					
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33																					
34	103	Armann (59)	Germany	Eastern Saxony	EU/EEA	No	Regional	Pre-print	25 May - 30 Jun; 15 Sept- 13 Oct	Other	Convenience	Teachers and students	1779	0.6%; 0.6%	ELISA; CLIA; CMIA	EUROIMMUN; Diasorin Liaison; Abbott Laboratories	IgG	97.6%	99.3%	7	Low
35																					
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37	104	Reisinger (139)	Germany	Rostock	EU/EEA	No	City/local	Published	22-29 Apr	Other	Convenience	Children and mothers	401	2.90%	ELISA	EUROIMMUN	IgA; IgG	Not reported	Not reported	3	High
38	105	Tsitsilonis (42)	Greece	Athens	EU/EEA	No	City/local	Published	15 Jun - 15 Jul	Other	Convenience	Employees and students	2500	0.93% (0.27, 2.09) ³	CLIA	Roche Diagnostics	Total Abs	100%	99.81%	5	Medium
39																					
40	106	Lastucci (140)	Italy	Prato	EU/EEA	No	Regional	Published	1 May - 31 May	Multiple	Random	Work-from-home; Support service	1828	1% (0.3-2.0); 1.4% (0.7-2.2)	LFA	Hangzhou Laihe Biotech	IgM; IgG	Not reported	Not reported	2	High
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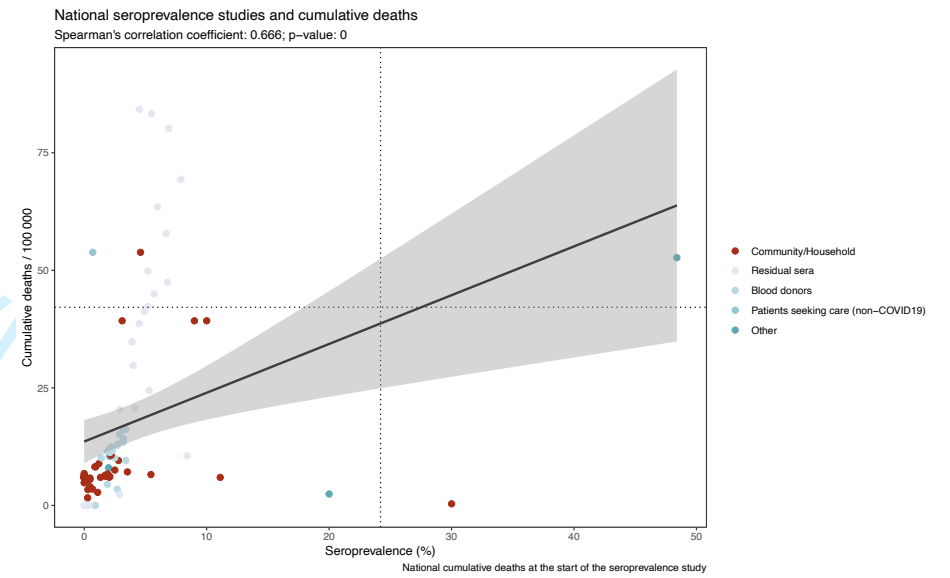
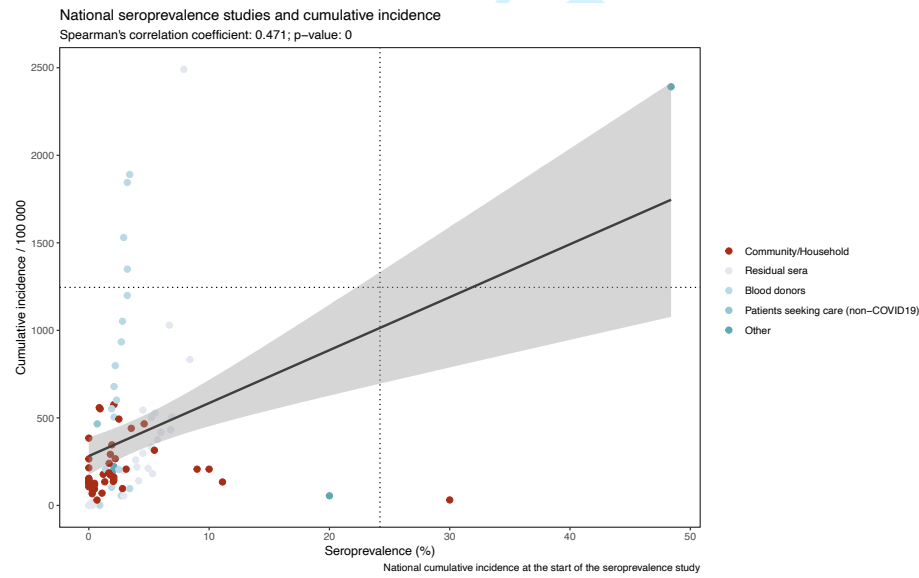
107	Soriano (141)	Spain	Madrid	EU/EEA	Yes	City/local	Published	27 Apr - 17 May	Multiple	Convenience	University staff, family members, community	674	13.8%	LFA	PCL Inc	IgM; IgG	Not reported	Not reported	High	
108	Montenegro (31)	Spain	Barcelona	EU/EEA	No	City/local	Published	21-24 Apr; 29 Apr - 6 May	Multiple	Random	HH/C samples; Patients seeking care (non-COVID-19)	311; 634	5.47% (3.44-8.58); 38.49% (34.78%-42.33%)	LFA; LFA; LFA	Livzon; Lysine; Sure Screen	IgM; IgG	Livzon=91.2%; Lysine=98.6%; SureScreen=91%	Not reported	9	Low
109	Emmenegger (27)	Switzerland	Canton of Zurich	non-EU/EEA	Yes	Regional	Pre-print	Mar - Jul	Multiple	Convenience	Blood donors; Patients seeking care (non-COVID-19);	Total: 33932; Blood donor cohort: 9,102; Patient cohort: 24,830;	BDS cohort [†] : April: 1.2%; May: 1.6%; July: 0.7%; Patient cohort [†] : March: 0.3%; April: 1.4%; May -July: 0.9%;	Tripartite Automated Blood Immunoassay (TRABI)	In house	IgG	100%	100%	5	Medium
110	Dopico (26)	Sweden	Stockholm	EU/EEA	No	City/local	Published [^]	4 Mar - 11 Dec	Multiple	Convenience	Blood donors; Pregnant women	2600, 2500	14.8% (12.2-18.0)	ELISA	In house	IgG	Spike 3SD:100% (95% CI [97.5-100.0]); Spike 6SD:100% (95% CI [97.5-100.0]); RBD 3SD:100% (95% CI [97.5-100.0]); RBD 6SD:98.0% (95% CI [94.2-99.3]);	Spike 3SD: 99.0% (95% CI [98.6-99.0]); Spike 6SD: 99.9% (95% CI [99.6-100.0]); RBD 3SD: 99.0% (95% CI [98.4-99.4]); RBD 6SD: 99.9% (95% CI [99.6-100.0])	5	Medium
111	Davis (142)	United Kingdom	London	non-EU/EEA	No	City/local	Pre-print	Jun	Other	Convenience	University staff and students	1882	6.6% (5.6-7.8)	LFA	SureScreen	IgM; IgG	89%	100%	4	Medium

* LuLISA: Luciferase Linked Immunosorbent Assay
[^] Initially reported to WHO EURO and ECDC in 2020 or in pre-print form and since published

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Supplementary Material

S1 Supplementary Methods

S1.1 Search strategy and selection criteria

We searched the WHO “COVID-19 Global literature on coronavirus disease” database (MEDLINE, ELSEVIER and the pre-print servers medRxiv and bioRxiv) (100) using search terms that included a range of criteria relating to seroprevalence surveys. The search terms and inclusion and exclusion criteria are described below (Table S1).

S1.2 Search terms

ti:sero\$urv* or ti:serosurv* or ti:seroepidemiolog* or ti:sero\$epidemiolog* or ti:serolog* or ti:seropositiv* or ti:seropositiv* or ti:serosurveillance or ti:sero\$surveillance or ti:seroprevalence or ti:sero\$prevalence or ti:antibody or ti:antibodies or ti:immunity or ti:immunoglobulin OR ab:sero\$urv* or ab:serosurv* or ab:seroepidemiolog* or ab:sero\$epidemiolog* or ab:serolog* or ab:seropositiv* or ab:sero\$positiv* or ab:serosurveillance or ab:sero\$surveillance or ab:seroprevalence or ab:sero\$prevalence

Table S1 Inclusion and exclusion criteria

Characteristics	Inclusion criteria	Exclusion criteria
Type of evidence	Published or unpublished scientific literature	Media reports (e.g. news items and press releases), reviews, assessed performance of a test, protocols
	Completed or ongoing serosurveys	Unrelated to seroprevalence
	Report seroprevalence estimates from one or multiple time points	
Population	Cross-sectional and cohort study designs	Case-control studies, case reports or reviews
	Studies of human participants, any age	Studies of non-human participants (i.e. animal studies)
	Population groups considered to be representative of the general population	Population groups considered to be unrepresentative of the general population as they had higher risk of infection (e.g. healthcare workers and other high-risk groups). Studies only of individuals with suspected (e.g. respiratory symptoms) or confirmed SARS-CoV-2 (RT-PCR laboratory confirmation)
Geographical location	WHO European region	Outside of WHO European Region
Languages	Any language	N/A

Table S2: Description of the quality assessment criteria used

Risk of bias criteria	Risk of bias assessment	Risk of bias scoring
Sampling frame: Representative of general population?	Poor (e.g hospital admissions, GP visits, pregnant women, employees)	0
	Weak (eg. blood donors)	1
	Good (e.g household sampling)	2
Sampling frame: Age profile included?	Does not cover those in target population (e.g study of 'all ages' excludes elderly or children)	0
	Study includes all those in target population	1
	Includes all ages (including children)	2
Sampling method: Were study participants sampled appropriate?	Non-random/non-exhaustive (including convenience sampling)	0
	Exhaustive	1
	Random	2
Sample size: Is sample size calculation described in methods?	Unclear	0
	Yes	1
Sample size: Was the sample size adequate?	If at least 300 samples in the study then adequate OR if at least 100 samples per age group (if stratified by age)	1
	If NONE of above OR no mention in methods/unclear	0
Test method: Use of more than one assays/test?	Yes	1
	No	0
Test method 1: Are tests sufficiently accurate? (no clinical validation)	Sensitivity/specificity acceptable* (i.e ELISA: Sn \geq 95%, Sp $>$ 97% OR POCT: Sn \geq 90%, Sp $>$ 97%)	1
	Sensitivity/specificity not acceptable (i.e ELISA: Sn $<$ 95%, Sp $<$ 97% OR POCT: Sn $<$ 90%, Sp $<$ 97%)	0
Test method 2: Use of commercial tests with clinical validation?	Sensitivity/specificity acceptable* (i.e ELISA: Sn \geq 95%, Sp $>$ 97% OR POCT: Sn \geq 90%, Sp $>$ 97%)	2
	Sensitivity/specificity not acceptable (i.e ELISA: Sn $<$ 95%, Sp $<$ 97% OR POCT: Sn $<$ 90%, Sp $<$ 97%)	1
Test method 3: Use of in-house assay	Sensitivity/specificity acceptable* (i.e ELISA: Sn \geq 95%, Sp $>$ 97% OR POCT: Sn \geq 90%, Sp $>$ 97%)	2
	Sensitivity/specificity not acceptable (i.e ELISA: Sn $<$ 95%, Sp $<$ 97% OR POCT: Sn $<$ 90%, Sp $<$ 97%)	1
	No results reported	0
Data analysis: Were the results adjusted according to sensitivity/specificity of the serological test?	Yes and Confidence intervals presented	2
	Yes but no Confidence intervals presented	1
	No/Unclear	0
Overall risk of bias	High risk of bias	1-3
	Moderate risk of bias	4-6
	Low-risk bias	$>$6

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3 **S2 Supplementary Figures**
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6 **Supplementary figure S1 Forest plot of the seroprevalence of SARS-CoV-2 antibodies in**
7 **Community/Household samples with corresponding 95% confidence intervals in WHO**
8 **European Region (1/1/2020-31/12/2020)**
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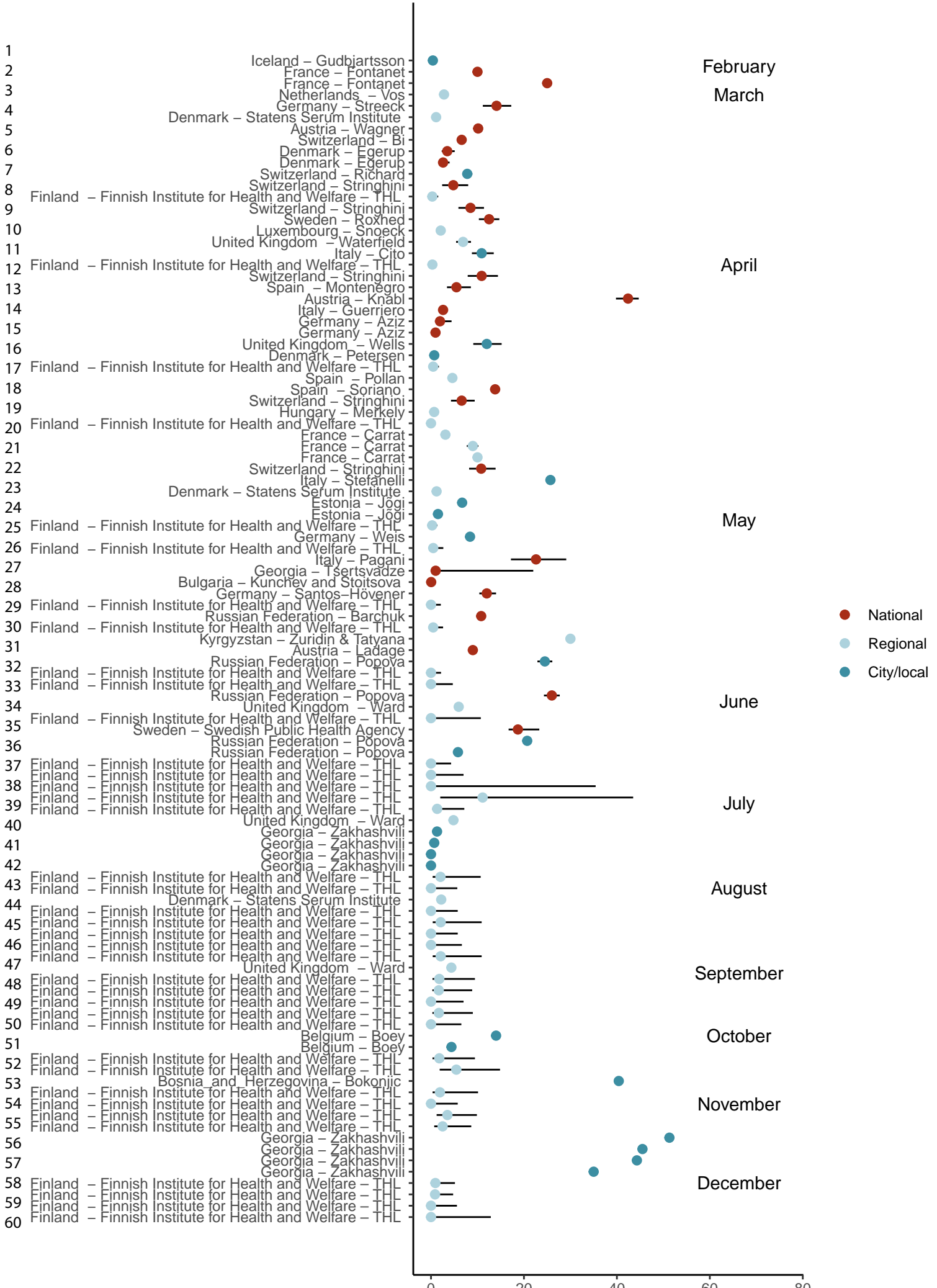
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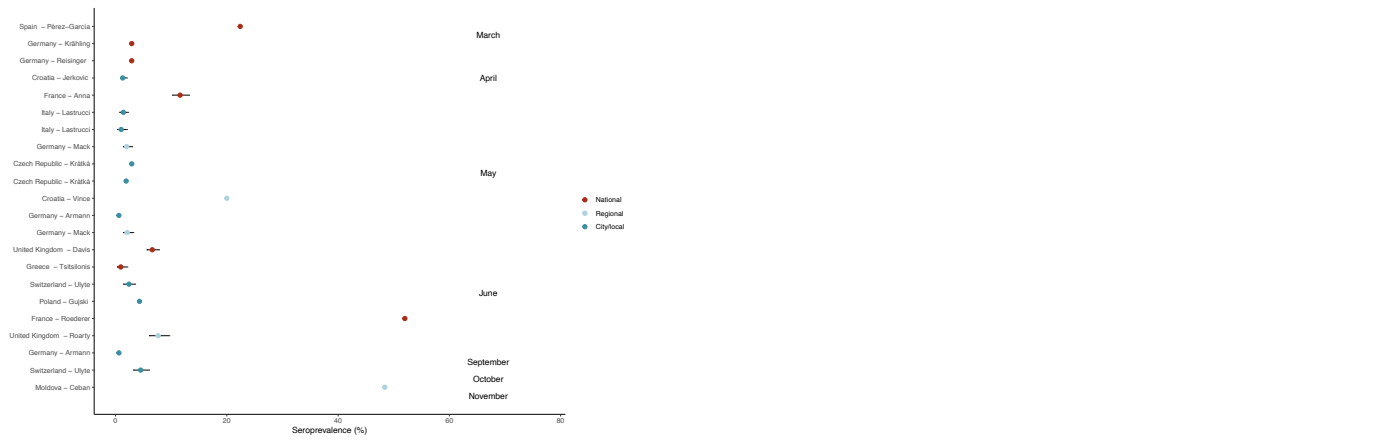
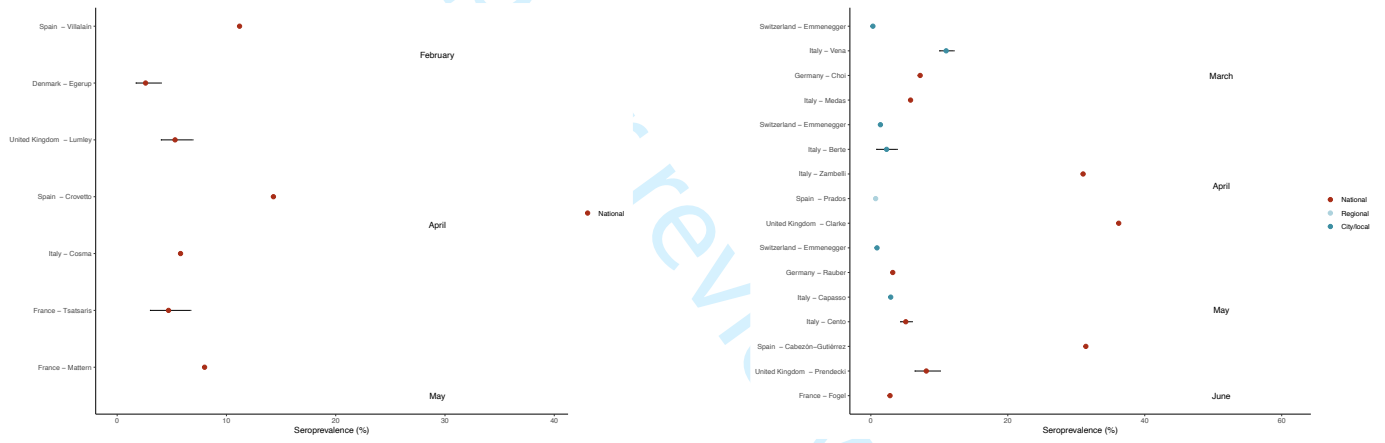
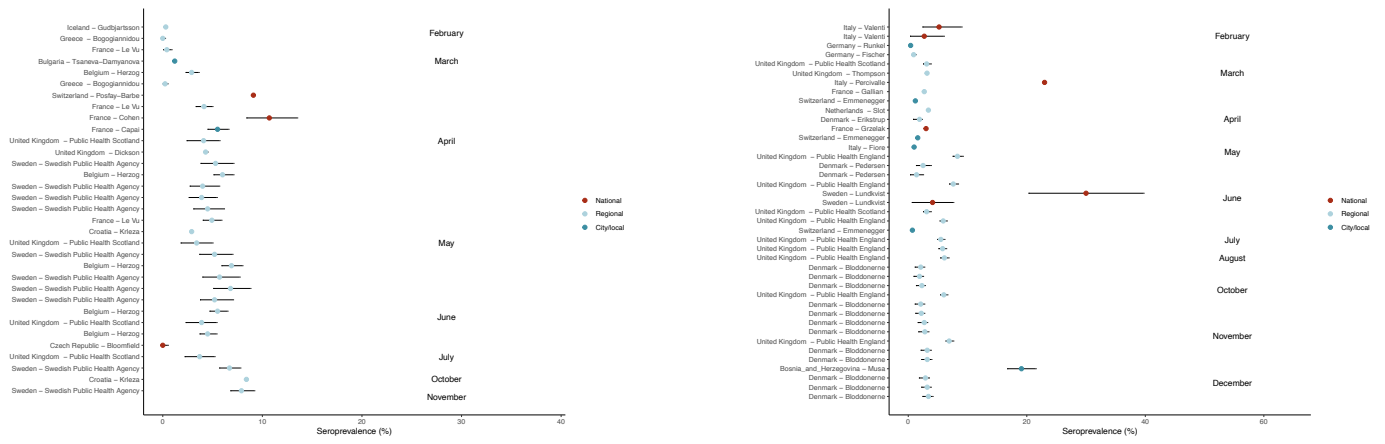
13 **Supplementary figure S2: Forest plot of the seroprevalence of SARS-CoV-2 antibodies in (Top**
14 **to bottom, Left to Right) a) Residual sera b) Blood donors c) Pregnant or Parturient women d)**
15 **Patients seeking care (non-COVID) and e) Other populations**
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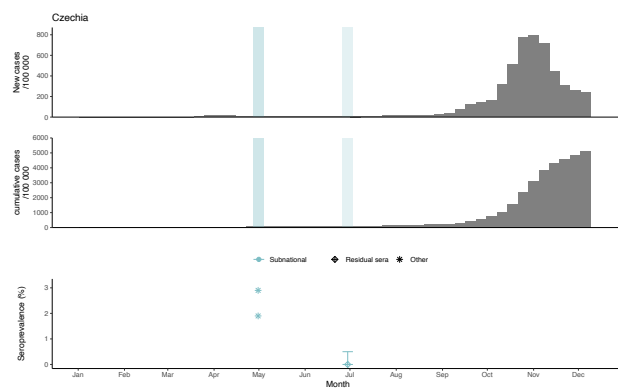
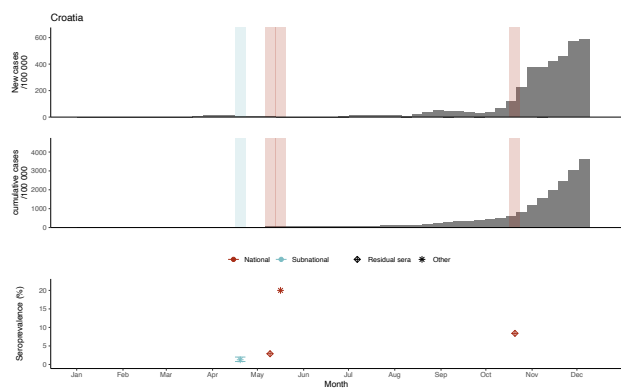
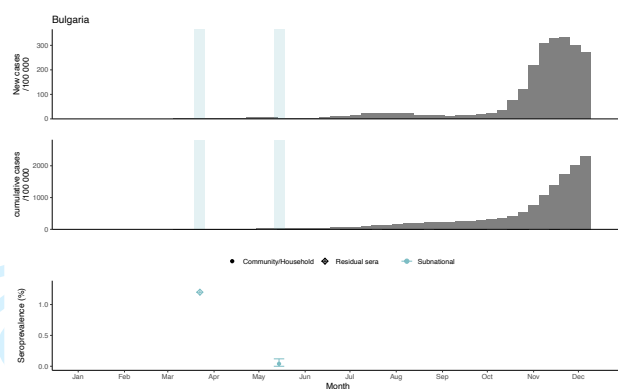
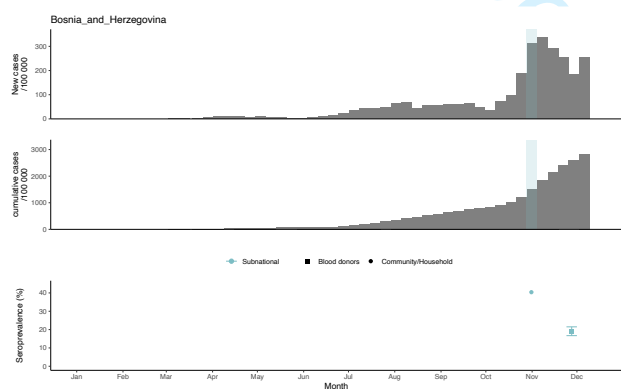
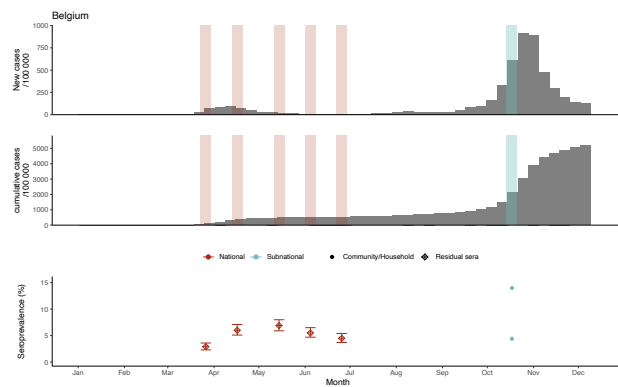
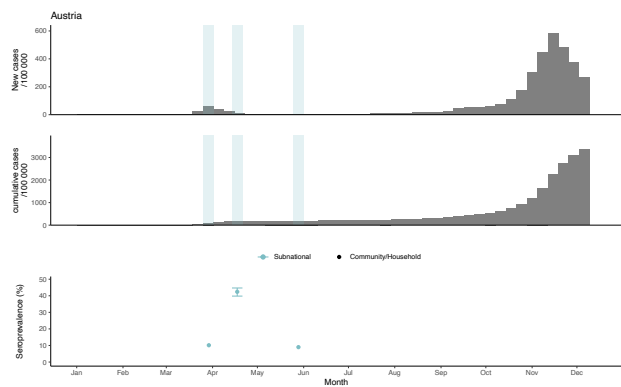
20 **Supplementary figure S3 Time point of conducted sero-epidemiology studies in relation to**
21 **country epidemic activity**
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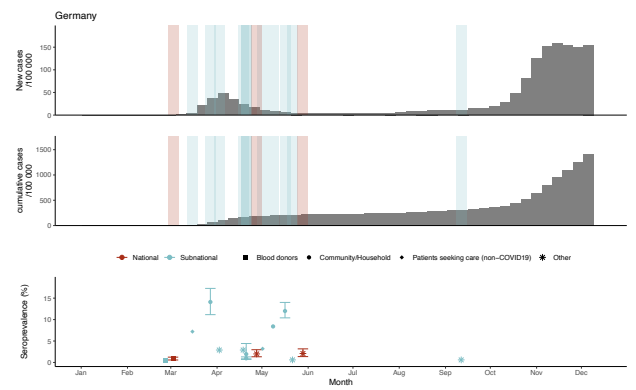
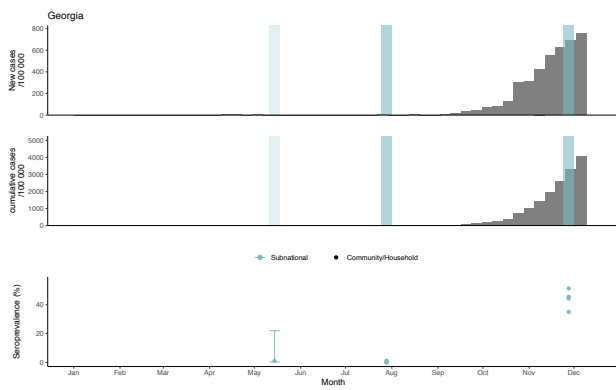
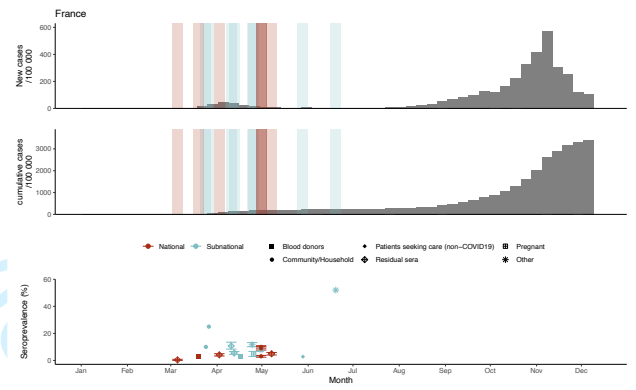
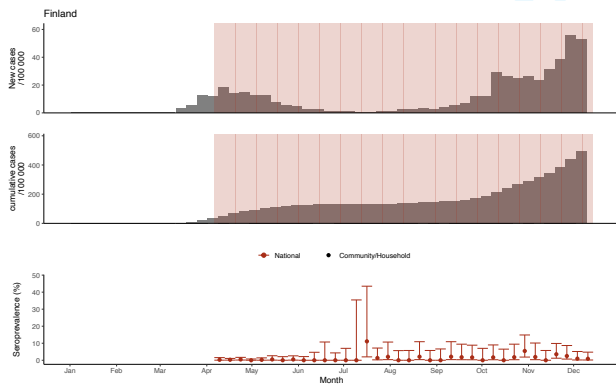
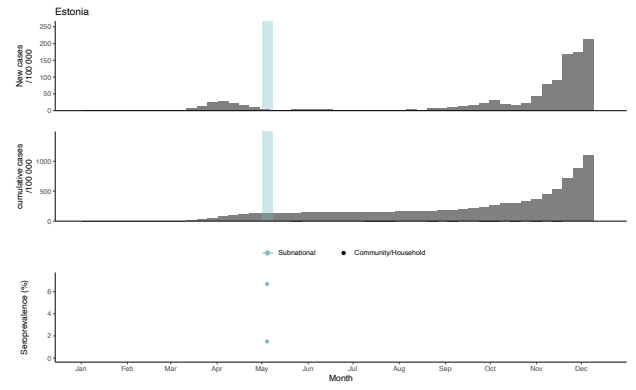
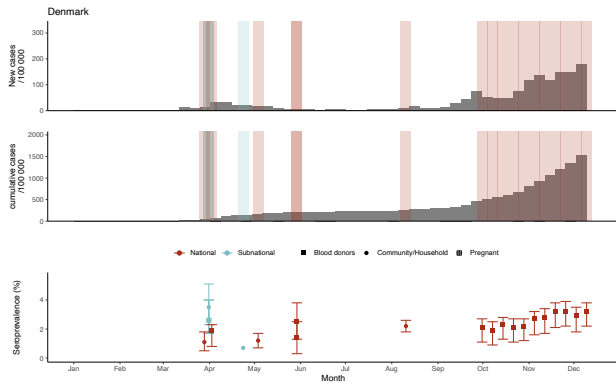




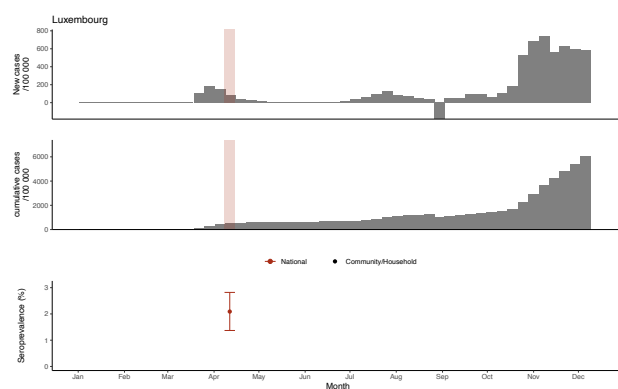
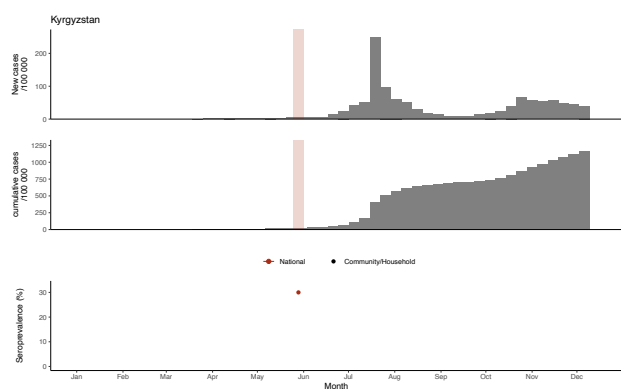
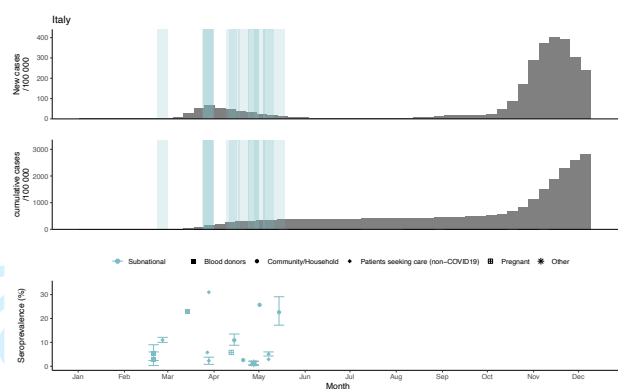
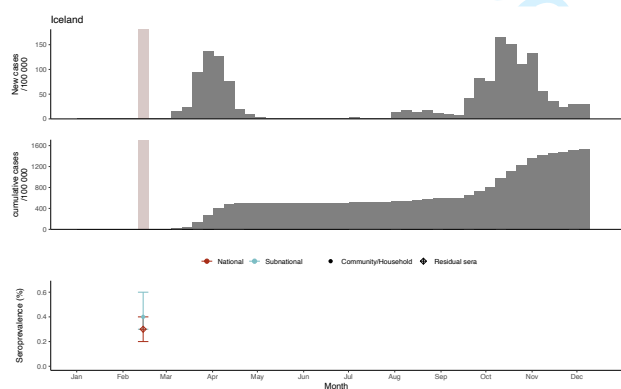
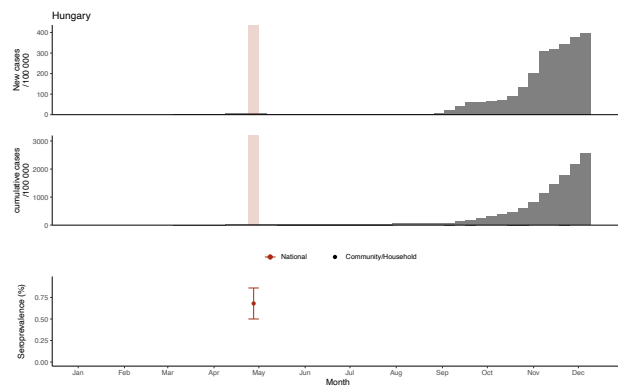
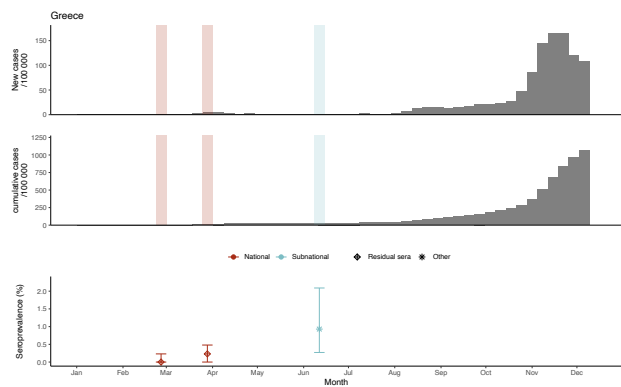
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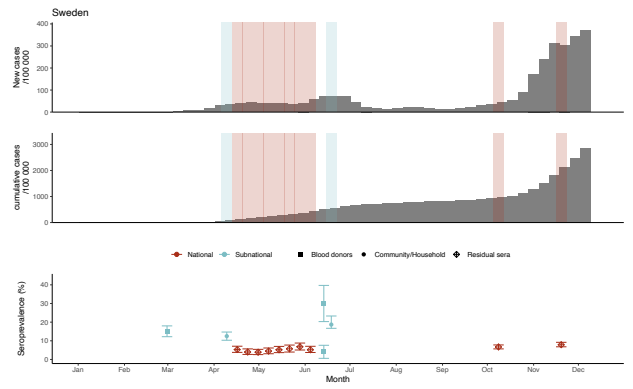
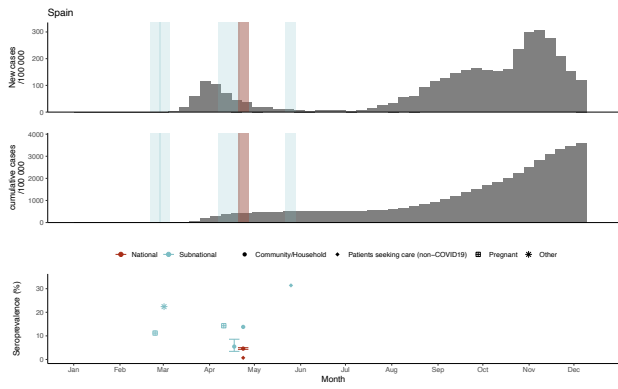
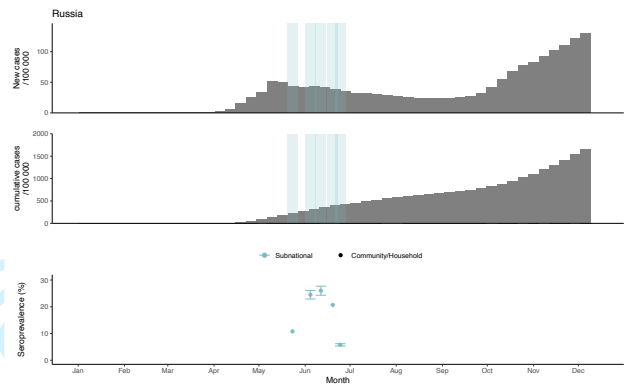
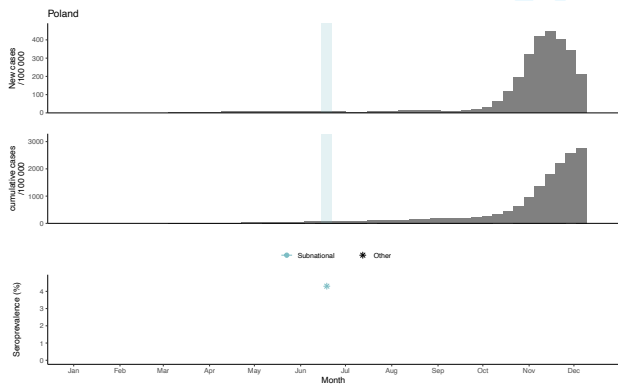
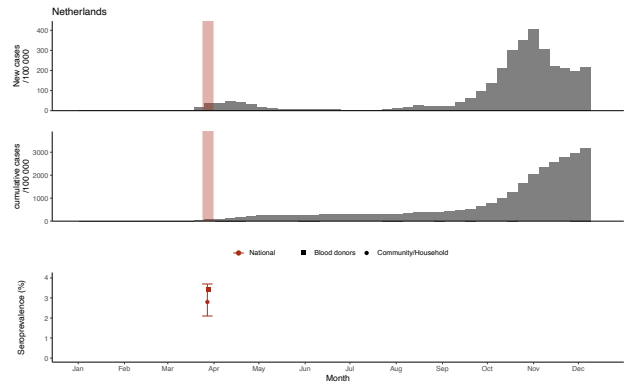
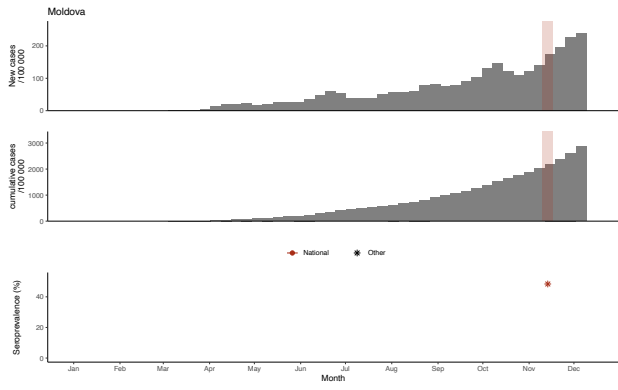
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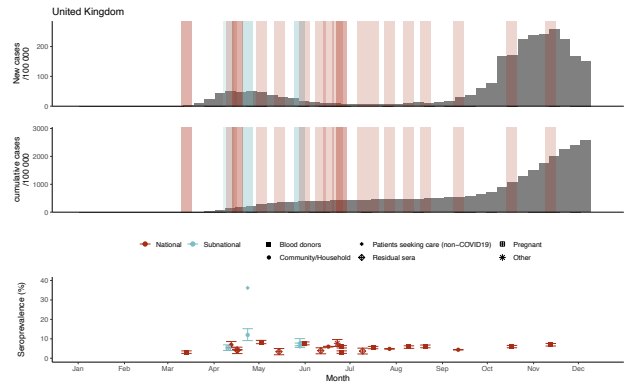
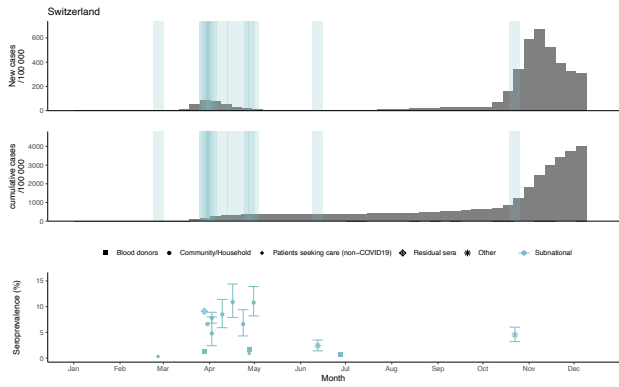
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PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Page 1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Page 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Page 6
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 7
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Page 7, Supplementary Material 2
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Page 7
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Page 7, Supplementary Material 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Page 8
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Page 8 and 9
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Page 8 and 9
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Page 8 and 9
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Page 8 and 9, Supplementary Table 1
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Page 8 and 9
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Page 8
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Page 8
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Page 8 and 9
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Page 8 and 9
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Page 8 and 9



PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	N/A
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Page 8 and 9, Supplementary Table 1
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Page 9, Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Figure 9
Study characteristics	17	Cite each included study and present its characteristics.	Table 1, Supplementary Table 2, Figure 2
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Page 17, Supplementary Table 1
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Table 1, Supplementary Table 2, Figure 3.
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Page 17, Supplementary Table 1
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Page 9-16, Figure 3
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Page 9-16, Figure 3
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Page 9-16, Figure 3
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Page 17-20
	23b	Discuss any limitations of the evidence included in the review.	Page 20-21
	23c	Discuss any limitations of the review processes used.	Page 20-21
	23d	Discuss implications of the results for practice, policy, and future research.	Page 21
OTHER INFORMATION			



PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Page 7
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Page 7
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Page 7
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Page 23
Competing interests	26	Declare any competing interests of review authors.	Page 23
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Supplementary Table 2

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71

For more information, visit: <http://www.prisma-statement.org/>

BMJ Open

A systematic review of seroprevalence of SARS-CoV-2 antibodies and appraisal of evidence, prior to the widespread introduction of vaccine programmes in the WHO European Region, January - December 2020

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2022-064240.R1
Article Type:	Original research
Date Submitted by the Author:	30-Jul-2023
Complete List of Authors:	Vaughan, Aisling; World Health Organization Regional Office for Europe Duffell, Erika; European Centre for Disease Prevention and Control Freidl, Gudrun; World Health Organization Regional Office for Europe Lemos, Diogo; World Health Organization Regional Office for Europe Nardone, Anthony; Epiconcept SAS Valenciano, M; Epiconcept SAS Subissi, Lorenzo; World Health Organization Bergeri, Isabel; World Health Organization Broberg, Eeva ; European Centre for Disease Prevention and Control Penttinen, Pasi; European Centre for Disease Prevention and Control Pebody, Richard; World Health Organization Regional Office for Europe Keramarou, Maria; European Centre for Disease Prevention and Control
Primary Subject Heading:	Public health
Secondary Subject Heading:	Epidemiology
Keywords:	Epidemiology < INFECTIOUS DISEASES, Public health < INFECTIOUS DISEASES, INFECTIOUS DISEASES, COVID-19, Systematic Review

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3 **A systematic review of seroprevalence of SARS-CoV-2 antibodies and appraisal of evidence,**
4 **prior to the widespread introduction of vaccine programmes in the WHO European Region,**
5 **January - December 2020**
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9 Vaughan A ¹, Duffell EF ², Freidl GS ¹, Lemos DS ¹, Nardone A ³, Valenciano M ³, Subissi L⁴, Bergeri I ⁴,
10 Broberg E ², Penttinen P ², Pebody R ¹, and Keramarou M ²
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19

20
21 **ABSTRACT**
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23 **Objectives**
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25 Systematic review of SARS-CoV-2 seroprevalence studies undertaken in the WHO European Region to
26 measure pre-existing and cumulative seropositivity prior to the roll out of vaccination programmes.
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29 **Design**
30

31 A systematic review of the literature
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33 **Data sources**
34

35 We searched MEDLINE, EMBASE and the pre-print servers medRxiv and bioRxiv within the “COVID-
36 19 Global literature on coronavirus disease” database using a predefined search strategy. Articles were
37 supplemented with unpublished WHO-supported Unity-aligned seroprevalence studies and other studies
38 reported directly to WHO Regional Office for Europe and ECDC.
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44 **Eligibility criteria**
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46 Studies published before the widespread implementation of COVID-19 vaccination programmes in January
47 2021 among the general population and blood donors, at national and regional levels.
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50 **Data extraction and synthesis**
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3 At least two independent researchers extracted the eligible studies; a third researcher resolved any
4 disagreements. Study risk of bias was assessed using a quality scoring system based on sample size,
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7 sampling and testing methodologies.
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9 **Results**

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11 In total, 111 studies from 26 countries published or conducted between 01/01/2020 and 31/12/2020 across
12
13 the WHO European Region were included. A significant heterogeneity in implementation was noted across
14
15 the studies, with a paucity of studies from the east of the Region. Sixty-four (58%) studies were assessed
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17 to be of medium to high risk of bias. Overall, SARS-CoV-2 seropositivity prior to widespread community
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19 circulation was very low. National seroprevalence estimates after circulation started ranged from 0% to
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21 51.3% (median 2.2% (IQR 0.7-5.2%); n=124), while sub-national estimates ranged from 0% to 52%
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23 (median 5.8% (IQR 2.3-12%); n=101), with the highest estimates in areas following widespread local
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25 transmission.
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28 **Conclusions**

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30 The low levels of SARS-CoV-2 antibody in most populations prior to the start of vaccine programmes
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32 underlines the critical importance of targeted vaccination of priority groups at risk of severe disease, while
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34 maintaining reduced levels of transmission to minimize population morbidity and mortality.
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39 **STRENGTHS AND LIMITATIONS OF THIS STUDY**

- 40
- 41 • This study provides a comprehensive systematic review of SARS-CoV-2 seroprevalence literature
 - 42 of all languages, and unpublished data.
 - 43 • Thorough literature search of major electronic databases and reporting as per Preferred
 - 44 Reporting Items for Systematic Reviews and Meta-Analyses guidelines.
 - 45 • Due to heterogeneity between studies including sampling frame, population and stage of
 - 46 epidemic at time of serosurvey results are described narratively.
 - 47 • Seroprevalence may be underestimated as antibody waning was not taken into account.
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INTRODUCTION

The novel virus, Severe Acute Respiratory Syndrome–Coronavirus–2 (SARS-CoV-2) was first identified in Wuhan, China in December 2019 and spread rapidly around the world. At that time, the transmissibility, population susceptibility, clinical spectrum and infection-severity of this novel virus were all unknown. By 1 January 2021, approximately 83 million confirmed cases were reported globally, while in the WHO European Region, there were 4.9 million cases (1). However, notified cases and deaths are an underestimate of the true number of infections for reasons including clinical presentation with a large proportion of asymptomatic or mildly symptomatic cases, testing and reporting strategies and health care seeking behaviour (2). Asymptomatic infection has been reported in many studies with the proportion ranging from 6 to 41% (3-5) so a significant proportion of SARS-CoV-2 infections will be missed through case-based surveillance systems. (6).

Seroprevalence studies, which measure SARS-CoV-2 antibodies, can provide an important complement to routine surveillance, particularly as part of the assessment of novel emerging respiratory pathogens. Seroprevalence surveys are essential to assess the true-extent of prevalence of pre-existing cross-reactive antibodies in the population; to measure population age-specific and geographic cumulative seroincidence as the novel virus spreads and to contribute to estimating infection-severity. As the majority of SARS-CoV-2 infected individuals have a detectable humoral immune response on average 10-14 days after symptom onset and most individuals seroconvert within 3-4 weeks of infection (7), and anti-SARS-CoV-2 antibodies are predictive of immune protection (8, 9), seroprevalence studies can provide an indication of population levels of humoral immunity and inform public health policies.

Since the start of the COVID-19 pandemic, there has been a rapid accumulation of seroepidemiological studies describing the seroprevalence of SARS-CoV-2. This review aims to provide a comprehensive review of studies conducted in the WHO European Region between 1 January and 31 December 2020 in the general population, with the aim to synthesize evidence on the extent of transmission across the region

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3 and population immunity to this newly emerging infection before the start of the COVID-19 vaccination
4 programmes. As SARS-CoV-2 continues to circulate, understanding the age-specific population
5 seropositivity remains critical for policymakers and public health officials to make informed decisions on
6 optimal public health interventions (10).
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11 **METHODS**

12 **Search strategy**

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14 We searched MEDLINE, WHO COVID, EMBASE and the pre-print servers medRxiv and bioRxiv within
15 the WHO “COVID-19 Global literature on coronavirus disease” database on 21 October 2020 and 12
16 January 2021. The searches spanned the period 1 January - 31 December 2020 and was not restricted by
17 language. We supplemented these articles with WHO-supported Unity seroprevalence studies and
18 unpublished studies reported to WHO Regional Office for Europe and ECDC. The selection process
19 followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines
20 (11). The full search strategy, search terms as well as inclusion and exclusion criteria are described in
21 Supplementary Material S1.
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32 **Data extraction**

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34 We combined the references from all databases, removed duplicates and imported the remaining articles
35 into Rayyan software (12) for screening of titles and abstracts according to the inclusion and exclusion
36 criteria (Supplementary Table S1). After the initial screening of title and abstracts, two independent
37 researchers assessed full-text publications for eligibility. Data from pre-print articles were extracted and
38 later replaced with data from published articles, where necessary. At least two independent researchers
39 extracted the eligible studies; a third researcher resolved any disagreements on assessment of eligibility or
40 extraction. We extracted the following data: first author, publication date, country, region, period of study,
41 population type, population age, sampling method, sample size, laboratory methods used, confirmatory
42 testing, test performance, crude and adjusted point seroprevalence estimates, antibody type and analysis
43 methodology (16-131). Comparison was made with weekly laboratory confirmed case and death reports.
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Study quality assessment

We used a modified Joana Briggs quality assessment scoring system to assess the overall risk of bias of each study (13). The criteria included: a) the sampling frame (to assess representativeness of the general population); b) stratification (age, sex or population); c) recruitment method (random, convenience), d): adequacy of sample size, e): serological methods and validation; f) and statistical analyses (adjustment of results to account for the sensitivity and specificity of the test). A cumulative quality score classified the overall risk of bias of each study into high risk of bias (1-3), medium risk of bias (4-6) or low risk of bias (>6). Two independent researchers conducted the quality assessment; a third researcher resolved any disagreements. See Supplementary Table S2 for more details on the quality criteria. For the purposes of quality assessment, the threshold for acceptable test performance was $\geq 95\%$ sensitivity and $>97\%$ specificity for laboratory assays and $\geq 90\%$ sensitivity and $>97\%$ specificity for point-of-care tests (14).

Data analysis

We used descriptive statistics to summarize estimates by subgroup (median and inter-quartile range (IQR). We generated forest plots to display the data and explore variations according to specific characteristics, including time, geographic location and population group. Correlation between cumulative incidence and cumulative deaths and seroprevalence estimates from studies of the general population was explored using Spearman's rank correlation. We compared seroprevalence estimates from studies of the general population and the cumulative incidence and deaths at the start of each study. Analyses were performed in Microsoft Excel (version 2016) and R version 4.0.4.

Patient and public involvement

No patient involved

RESULTS

Literature search

The literature search resulted in 4,063 studies. After deduplication, application of inclusion and exclusion criteria and supplementation with articles from other sources, a total of 111 studies were included in this review. Of these, 77 were published articles, 19 were preprints, nine were institutional reports, and six were studies were identified through reporting of unpublished results to WHO or ECDC. See Figure 1 PRISMA flow diagram study selection.

Study characteristics

The 111 studies included 224 seroprevalence estimates from 26 of the 53 countries in the WHO European Region (Figure 2). The majority of studies (n=82; 74%) were conducted in 19 EU/EEA countries, while 29 studies (26%) conducted in seven non-EU/EEA countries (Bosnia and Herzegovina, Georgia, Kyrgyzstan, Republic of Moldova, Russian Federation, Switzerland and the United Kingdom) (Figure 2; Table 1). Fifty-six (50%) studies were aligned with the World Health Organization Unity population-based sero-epidemiological investigation criteria related to study design, data collection and analysis (15). The majority of studies (n=69, 62%) used non-random or convenience sampling of the population. Forty-one (37%) studies used random sampling, while one study did not report sampling methodology. Characteristics and details of included studies are shown in Table 1 and Table S1, respectively.

Table 1: Study characteristics

Characteristics	Number of studies	%
Total	111	100
Study characteristics		
Country		
WHO European Region (EU/EEA)	82	74
WHO European Region (outside of EU/EEA)	29	26
WHO UNITY alignment		
Unity-aligned	56	50
Not Unity-aligned	55	50
Publication type		
Peer-reviewed article	77	69
Pre-print	19	17
Institutional report	9	8
Not yet published	6	5
Geographical level		
National	33	30
Regional	27	24
City/Local	50	44
Multiple	1	1
Sampling strategy		

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3	Convenience	69	62
4	Random	41	37
5	Not reported	1	1
6	Population type		
7	Household/Community	45	41
8	Residual sera	13	12
9	Blood donors	16	14
10	Patients seeking healthcare (non COVID-19)	13	12
11	Pregnant or parturient women	7	6
12	Other/multiple	23	21
13	Quality assessment		
14	Low risk of bias	41	37
15	Medium risk of bias	40	36
16	High risk of bias	24	22
17	N/A	6	5
18	Sample size		
19	<1000	45	41
20	>=1000	66	59
21	Laboratory characteristics		
22	Serological method		
23	ELISA	55	50
24	CMIA/CLIA	42	38
25	LFA	25	23
26	MN	10	9
27	Other	8	7
28	Not reported	2	1
29	Type of assay		
30	Commercial	90	81
31	In-house	26	23
32	Not reported	2	1

*ELISA – Enzyme linked immunoassay; CMIA/CLIA - Chemiluminescence Microparticle Immunoassay/ Chemiluminescence Microparticle Immunoassay; LFA – Lateral flow immunoassay; MN – Microneutralization assay

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3 In total, 72 (65%) of the studies provided representative estimates from the general population, of which
4 sample frames included 45 (41%) studies of household or community samples, 13 (12%) residual sera, 13
5 (12%) patients seeking healthcare for non-COVID-19 related issues, seven (6%) pregnant or parturient
6 women. Sixteen (14%) studies sampled blood donors as a proxy for the general population while 23 (21%)
7 sampled other or multiple populations. Studies were conducted at differing geographical levels within a
8 country, including at the national level (n=33; 30%), regional level (n=27; 24%) and city or local level
9 (n=50; 44%). One study reported both national and regional estimates
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20 Over half of the studies used one serological assay (74; 67%) while 34 (31%) used at least two different
21 assays. In 82 studies (74%), commercial assays from various sources were used, 20 (18%) studies used an
22 in-house assay only and six studies (5%) used both a commercial and in-house developed assay. The test
23 method was not reported in two studies. An Enzyme-linked Immunosorbent assay (ELISA) was the method
24 most commonly employed (n=55, 50%), followed by Chemiluminescent immunoassay (CLIA) or
25 Chemiluminescence Microparticle Immunoassay (CMIA) (n=42, 38%) and lateral flow immunoassays
26 (LFAs) (n=25, 23%). Seventeen studies (15%) used LFAs exclusively. Ten studies (9%) employed in-
27 house microneutralization assays to assess the neutralizing ability of SARS-CoV-2 antibodies.
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39 Of 90 studies that used a commercial assay, 33 studies (37%) reported the use of tests with acceptable
40 sensitivity and specificity. Of those that independently validated assay performance (n=41, 46%), 14 (34%)
41 reported acceptable sensitivity and specificity, while 27 (66%) did not meet these thresholds. Of the 20
42 studies that used an in-house assay, nine (45%) reported an acceptable test performance, four (20%)
43 performed below these thresholds and seven (35%) did not report on test performance. The majority of
44 studies (n=83, 75%) did not report adjustment for test sensitivity or specificity in their analysis.
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5 Based on our quality scoring system (Supplementary Table S2), 81 studies (73%) were of high or medium
6 quality reflecting a low or medium risk of bias, respectively (medium quality: n=40, 36%; high quality
7 n=41, 37%) (Supplementary Table S3). A total of 24 studies (22%) were determined to be at high risk of
8 bias, largely due to non-random sampling frame, weak representativeness of the general population or lack
9 of adjustment for sampling bias or test performance.
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15 16 17 18 **Seroprevalence estimates**

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20 Seroprevalence estimates (n=88) from national studies ranged from 0% (CI: 0.0-0.7) in Finland in May (26)
21 to 51.3% in Georgia in December (28) (median 2.2% (IQR 0.7 – 5.2%); n=124) (Figure 3a), while
22 seroprevalence estimates from studies spanning regions, cities or towns (n=101) ranged from 0% (CI 0.0-
23 0.5%) in Czech Republic in August 2020 (28) to 52% in a Médecins Sans Frontières centre in Paris, France
24 during an outbreak with widespread community transmission in June 2020 (114) (median 5.8% (IQR 2.3-
25 12%); n=101) (Figure 3b).
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35 A total of 45 studies provided seroprevalence estimates (n=105) from community or household samples
36 and 39 studies (87%) were found to be of high or medium quality. Seroprevalence estimates ranged from
37 0% (CI: 0-0.7%) in Finland in May and to 51.3% in December 2020 in Georgia (28) (median 2.6% (IQR
38 0.5-10%) n=105) (Supplementary Figure S1).
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45 Thirteen studies screened residual clinical samples (29-42) between February and November 2020, of
46 which nine (70%) were of high or medium quality. Seroprevalence estimates (n=34) in this population
47 varied across countries ranging from 0% (CI 0-0.23) in Greece in March to 18.7% (CI 16.7-23.3%) in
48 Sweden in June (median 4.5% (IQR 3.5-5.9%); n=34) (Supplementary Figure S2a).
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3 Eighteen studies (17%) utilized blood donors as a proxy for the general population between February and
4 December 2020, of which 16 were of high or medium quality. Seroprevalence estimates (n=42) in blood
5 donors varied across countries, ranging from 0.4% in Germany between March and June (76) to 30% in
6 Tensta (Stockholm) following a period of high incidence in June (81) (median 5.8% (IQR 2.1-5.7%) n=42)
7 (Supplementary Figure S2b).
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15 Eight studies investigated the seroprevalence of SARS-CoV-2 in pregnant or parturient women, reporting
16 estimates ranging from 2.6% (CI 1.7-4%) and 14.3% between March and June 2020 (median 6.9% (IQR
17 5.1-12%); n=8) (102-108) (Supplementary Figure S2c). One study provided combined estimates of blood
18 donors and pregnant women of 14.8% in Sweden between March and December (130).
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26 Fourteen studies provided 16 estimates from individuals seeking healthcare for non-COVID-19 related
27 reasons and seven (50%) of these were medium or high quality. Estimates ranged from 0.3% in Zurich,
28 Switzerland in March (129) to 36.2% in London in April (100) (median 4.1% (IQR 2.1-8.8%); n=16) from
29 March to August 2020. The highest seroprevalence estimates (>10%) in this group were observed in three
30 patient groups investigated following local widespread community transmission, oncology patients (31%)
31 in Bergamo, Italy in April 2020 (92), oncology patients (31.4%) in Madrid between May and June 2020
32 (98) and haemodialysis patients (36.2%) in London in April and May 2020 (100) and patients (38.5%) in
33 Barcelona, Spain in April (128) (Supplementary Figure S2d).
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45 Forty-four (41%) studies reported seroprevalence estimates stratified by age. Seroprevalence estimates
46 varied considerably across age groups and estimates tended to be lower in children (<18 years) (39, 41,
47 52) and older age groups (>60 years) (36, 44, 50, 52, 69, 70, 132). Whilst a number of studies reported a
48 high seroprevalence in older age groups (>55 years) (29, 35, 36, 44, 73, 78, 97, 125), some studies also
49 reported a higher seroprevalence in younger age groups (<40 years) (41, 53, 73, 80). In studies that reported
50 seroprevalence estimates by sex, similar seroprevalence results were observed between females and males
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3 with the exception of a study in Italy (97), Russian Federation (46) and Kyrgyzstan (39) which each found
4 a higher seroprevalence in females.
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7 **Seroprevalence estimates over time**

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9 A number of studies provided seroprevalence estimates prior to, or at the early stages of the epidemic in
10 the country (Supplementary Figure S3). Of these, overall study estimates were largely below 10%, however
11 higher seroprevalence was noted in a number of population-specific, regional or local studies (16, 31, 32,
12 35, 36, 92, 111, 113), with suggestion of earlier undetected transmission in some countries (39, 107, 119,
13 130). A total of 16 studies reported seroprevalence estimates spanning multiple timepoints or stages of the
14 epidemic (23, 26, 28, 49, 52, 53, 55, 58, 61, 64, 65, 68, 79, 82-87, 116, 120, 123, 128, 129). In a serial
15 cross-sectional study in France (61), residual blood sampled before, during and after a national lockdown
16 showed a seroprevalence of 0.41%, 4.14%, and 4.93%, respectively. In Georgia, in a community sample,
17 an increase in seroprevalence from 0-1.3% in August 2020 to 35-51.3% in the same regions in December
18 2020 was noted (28). A seroprevalence study in blood donors conducted in Milan between February and
19 April 2020 during a period of intense transmission found an increase in seroprevalence from 2.7% (95%
20 0.3-6.0%) to 5.2% (95% 2.4-9.0) , with an adjusted rate of increase in antibodies (IgG) of $2.7 \pm 1.3\%$ per
21 week as social distancing measures were gradually implemented (79). While in Finland, weekly testing of
22 blood donors from April 2020 onwards showed a consistently low seroprevalence in the general population
23 over time (0.28% (0.05–1.55) in early April 2020 to 0% (0–12.87) in late December 2020 (67).
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43 **Correlation between seroprevalence and cumulative incidence**

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45 The relationship between seroprevalence and reported SARS-CoV-2 laboratory confirmed cumulative case
46 and deaths incidence was also explored. While seroprevalence from national studies correlated moderately
47 with cumulative incidence (Spearman's rank correlation coefficient, 0.471) (Figure 4a), a stronger
48 correlation was observed between seroprevalence estimates and cumulative SARS-CoV-2 deaths
49 (Spearman's rank correlation coefficient, 0.666) (Figure 4b).
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DISCUSSION

In this study we report the results of 111 studies, including 224 seroprevalence estimates from 26 countries in the WHO European Region undertaken until December 2020, prior to the implementation of national COVID-19 vaccine campaigns. A large variation in study methodologies was noted across the studies, with an overrepresentation of studies from high-income countries in Western Europe.

Overall, population-wide seroprevalence estimates were low (below 10%) across the Region early in 2020 before the onset of widespread community transmission and remained low across the Region throughout 2020, despite circulation of SARS-CoV-2 over this period. Higher estimates were observed at a regional or local level in populations that had experienced intense community transmission (up to 52%). Furthermore, a positive correlation between seroprevalence estimates and national cumulative incidence was observed, with a stronger correlation between seroprevalence and cumulative mortality.

The wide variation in seroprevalence estimates across the region are likely to reflect many factors including the differences in the population studied, local stage of the epidemic and the public health and social measures implemented in response to the epidemic at that time. The general low seroprevalence both at the start of the pandemic and at the end of 2020 is in line with a number of global systematic review conducted to date (133-136) and together indicate that the majority of the proportion of the population in the WHO European Region were and remain susceptible to infection one year after the identification of SARS-CoV-2 and prior to the start of national vaccination campaigns. In a global systematic review, Chen et al. estimated a seroprevalence of 4.2% (2.7-5.8) across the European Region until August 2020 (135) while Rostami et al. estimated a pooled prevalence of 3.17% (1.96-4.38), 4.41 % (2.20-6.61), 5.27% (3.97-6.57) in Western, Southern and Northern Europe, respectively (134). In the same period, Bobrovitz et al. reported a pooled estimate of 1.6% (1.1-5.2%) seroprevalence in studies conducted across Central Europe, Eastern Europe and Central Asia (137) and 12.2% (4.5-25.4%) from population-wide studies conducted until December 2020 (133).

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3 A number of studies reported low seroprevalence in younger and older age groups, a finding observed in
4 other systematic reviews (133, 135, 138). Such findings have important implications, as groups such as
5 the elderly are at higher risk of severe outcome following infection – and lack of cross-protective immunity
6 indicates that all age-groups will anticipate seeing high infection attack rates without implementation of
7 measures such as vaccination of priority groups, together with strengthening of public health and social
8 measures to reduce SARS-CoV-2 transmission.
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18 When reviewed alongside case notification data, seroprevalence estimates can provide greater insight into
19 the local evolution of the pandemic. In this review, a positive correlation between seroprevalence estimates
20 and national cumulative incidence in a number of countries was observed, suggesting that seroprevalence
21 is a reflection of the duration and intensity of community transmission. It should be noted however that
22 during the initial peak of infections in Europe in the spring of 2020, testing in many countries was not yet
23 optimal and case notification data at this time are unlikely to provide a robust proxy for incidence in many
24 instances. In line with this, several studies found seroprevalence estimates to be higher than the
25 corresponding cumulative incidence of SARS-CoV-2 infections, suggesting a substantial under-
26 ascertainment of infection through notifications, due to a number of factors including the asymptomatic or
27 mild nature of disease, healthcare seeking behaviour, lack of testing capacity and testing and reporting
28 strategies. Indeed, we also found a stronger association between seroprevalence and cumulative case
29 mortality than cumulative case incidence, providing further evidence to support the suggestion of case
30 under-ascertainment, as laboratory confirmed mortality surveillance for COVID-19 is likely to be more
31 comprehensive.
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50 The varying quality of studies in this review reflects the challenge of conducting seroepidemiological
51 studies of high quality. Indeed, this review found that only 50% of all studies undertaken in the WHO
52 European region in 2020 were aligned with the WHO Unity study initiative. Few of the national (n=5; 15%)
53 or regional (n=2; 7%) studies were determined to be of high risk of bias, while 17 (34%) of studies
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3 conducted at a local level (cities or towns) were graded as such. This variation may be explained by the
4 level of resources and epidemiological support available to studies conducted at the regional or national
5 level.
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9 The majority of studies identified in this review utilised convenience rather than random sampling, which
10 may have reduced the true representativeness of the estimates derived, though such convenience sampling
11 is likely to provide a good estimate of population exposure for widely circulating viral infections. Many
12 studies also included individuals that were not fully representative of the population under study, which
13 may have introduced bias. For example, this review included studies that explored seroprevalence in the
14 general population by utilising various proxy populations such as blood donors and residual blood. Blood
15 donors are known to differ from the general population in that they are often a young, healthy adult
16 population selected on the basis of lack of recent infection (139) and seroprevalence may therefore be over
17 or underestimated in this group. Residual sera, on the other hand, derives from individuals who have sought
18 health care and may therefore have pre-existing comorbidities or be at higher risk of SARS-CoV-2
19 infection. However, we found that seroprevalence estimates for these distinct populations are in good
20 agreement with the general population.
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37 We also found that there was a high degree of heterogeneity across serological assays used. The majority
38 of studies used commercial tests of varying sensitivity and specificity to detect SARS-CoV-2 targeted
39 antibodies, although some of these assays have now been shown to have excellent performance (140, 141).
40 However, under half of studies performed independent validation of these kits with internal controls and
41 serum panels and only 25% accounted for the sensitivity and specificity of the tests in their statistical
42 analyses. As SARS-CoV-2 serological tests have been found to have variable test performance (140, 141),
43 independent validation at local level in combination with use of an WHO International Standard and
44 Reference Panel for anti-SARS-CoV-2 antibody has been widely promoted as part of the Solidarity II
45 initiative (142, 143). Other options include the Joint Research Centre (144) reference materials for the
46 quality control of SARS-CoV-2 antibody tests. Use of these materials will allow for the potential correction
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3 for sensitivity and specificity during the statistical analysis, would allow for more robust estimates and
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5 greater comparability among countries in the region.
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9 Overall, the findings of this review highlight the need for international collaboration to standardise
10 approaches and support countries in conducting robust comparable studies. WHO, in collaboration with
11 technical partners, has developed the Unity studies (15)(90), a global seroepidemiology standardization
12 initiative for COVID-19, which aims to increase quality evidence-based knowledge in country and regions
13 for action through the availability of standardized seroepidemiology investigation protocols and antibody
14 assays. A primary aim of this global initiative is the provision of direct support to countries to develop
15 country specific protocols, with particular attention provided to low- and middle- income countries
16 (LMICs), and to support aggregation, comparison and analysis of robust Unity-aligned studies through
17 strong coordination between WHO Country offices, Regional offices and Headquarters. A large proportion
18 of the studies identified in this systematic review were conducted in Western European countries, with a
19 relative scarcity of seroprevalence studies from other countries by the end of 2020, an observation noted in
20 other systematic reviews (133-135, 138). This highlights the urgent need for enhanced capacity, the
21 provision of additional support to LMICs and the sharing of information to address the gap in knowledge
22 and tackle research inequity. To counteract the skewedness in the WHO European Region, the WHO Unity
23 protocols have been widely promoted by WHO and ECDC and technical support has been provided to tailor
24 the protocols to local contexts, together with laboratory and financial support to LMICs. In addition, WHO
25 and ECDC jointly established a network of approximately 300 public health professionals to facilitate
26 discussions in related to SARS-CoV-2 seroprevalence, promote timely sharing of results and knowledge
27 and further build capacity in the WHO European Region.
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51 This systematic review comprehensively describes the seroprevalence of SARS-CoV-2 in the first year of
52 the pandemic, prior to the widespread implementation of national vaccine programs. With the inclusion of
53 as yet unpublished data from LMICs, this review contributes to research equity across Member States
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3 income levels and provides a more representative overview of the situation in the WHO European Region
4 than would published studies alone. In addition, we evaluated the UNITY study alignment of studies to
5 assess quality and comparability.
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9 This review has some limitations. Firstly, there was significant heterogeneity among the studies, including
10 sampling frame, population and stage of epidemic at time of serosurvey, which makes comparability across
11 studies difficult. Due to such heterogeneity, we opted to not provide one pooled estimate nor conduct a
12 meta-analysis, as interpretation would be difficult and may not accurately reflect the picture in the WHO
13 European Region. Secondly, while population-based serological surveys can provide a more accurate
14 estimation of the overall rates of SARS-CoV-2 infection within a population, this approach does not
15 consider antibody waning, which cannot be easily accounted for as antibody levels vary depending on
16 disease severity (145) and longevity is expected to vary greatly across SARS-CoV-2 infected individuals
17 (146). In addition, while seroprevalence studies provide an estimate of population exposure, seropositivity
18 is not the only predictor of susceptibility to infection. Finally, due to the rapid accumulation of data related
19 to SARS-CoV-2 seroepidemiology and the advent of the 'preprint era', not all included studies have been
20 published and may therefore be subject to change upon peer review.
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36 Conclusion

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38 As SARS-CoV-2 continues to circulate, understanding the population seropositivity remains critical for
39 policymakers and public health officials to make informed decisions on optimal public health interventions,
40 such as lifting or tightening of restrictions and targeted vaccination (10, 147). In this study, we found
41 evidence that SARS-CoV-2 antibody seroprevalence across the WHO European Region was low prior to
42 widespread circulation and remained low in the general population during 2020. This suggests that much
43 of the population remained susceptible to infection prior to the implementation of national COVID-19
44 vaccine campaigns from early 2021 onwards. We also found variation in seroprevalence estimates between
45 and within countries during 2020, with evidence of increased prevalence in areas following high levels of
46 transmission and some association with incidence and mortality trends over time. It is clear that antibody-
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3 mediated 'herd immunity' through natural infection is not attainable in most countries and COVID-19
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5 vaccines should continue to be distributed widely and equitably to protect priority groups and the wider
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7 population. Given the issue of antibody waning, all efforts must be also directed towards well-informed and
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9 evidence-based implementation and maintenance of non-pharmaceutical interventions at a local and
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11 national level to stem any future waves of the pandemic. Indeed, as vaccine programs continue to be
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13 implemented, standardised seroprevalence studies will be instrumental to evaluate both natural and vaccine
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15 derived immunity overtime to guide public health actions and decision making.
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18 Seroprevalence studies have been of great value to COVID-19 pandemic response efforts, providing
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20 estimates of the true extent and dynamics of SARS-CoV-2 infection overtime and the lessons identified
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22 from COVID-19, in particular the need for standardised global serosurveillance systems, will inform future
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24 pandemic preparedness.
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Data sharing

The unpublished data supporting the findings of this study are available on the open source Zenodo repository <https://zenodo.org/communities/unity-sero-2021?page=1&size=20>.

Supplementary material

Supplementary material file is attached

Registration and protocol

Not registered. A protocol was not prepared

Declaration of interests

No competing interests

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Ethics statement

This systematic review of study data did not require ethical approval. This study does not involve human participants nor animal subjects.

Authors' Contributions

Conceptualisation: AV, ED, GF, RP, MK, PP, AN, MV, IB, LS, EB; Data curation: AV, GF, ED, MK, DL; Formal analysis: AV, GF, ED, MK; Investigation: AV, GF, ED, MK, AN, MV; Methodology: AV, GF, ED, MK, AN, MV, RP, PP, EB; Supervision: AV, GF, ED, MK, RP, PP; Writing – original draft: AV, ED, GF, RP, MK, PP, IB, LS, AN, MV, EB; Writing – review & editing: All authors

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Figure Legend

Figure 1: PRISMA Flow chart of SARS-CoV-2 seroprevalence study selection

Figure 2: Geographical distribution of SARS-CoV-2 seroprevalence studies published in the WHO European Region between 1 Jan – 31 Dec 2020

Table 1: Study characteristics

Figure 3: National (a) and sub-national (b) seroprevalence estimates of SARS-CoV-2 antibodies over time in the WHO European Region (1/1/2020-31/12/2021)

Figure 4: Correlation between seroprevalence point estimates from low to medium risk of bias studies and cumulative (a) incidence and (b) deaths in all populations, in the WHO European Region (1/1/2020-31/12/2020)

Table S1 Inclusion and exclusion criteria

Table S2: Description of the quality assessment criteria used

Table S3: Characteristics of eligible seroprevalence studies

Supplementary figure S1: Forest plot of the seroprevalence of SARS-CoV-2 antibodies in Community/Household samples with corresponding 95% confidence intervals in WHO European Region (1/1/2020-31/12/2020)

Supplementary figure S2: Forest plot of the seroprevalence of SARS-CoV-2 antibodies in (Top to bottom, Left to Right) a) Residual sera b) Blood donors c) Pregnant or Parturient women d) Patients seeking care (non-COVID) and e) Other populations

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3 **Supplementary figure S3:** Time point of conducted sero-epidemiology studies in relation to country
4 epidemic activity
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For peer review only

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Figure 1: PRISMA Flow chart of SARS-CoV-2 seroprevalence study selection

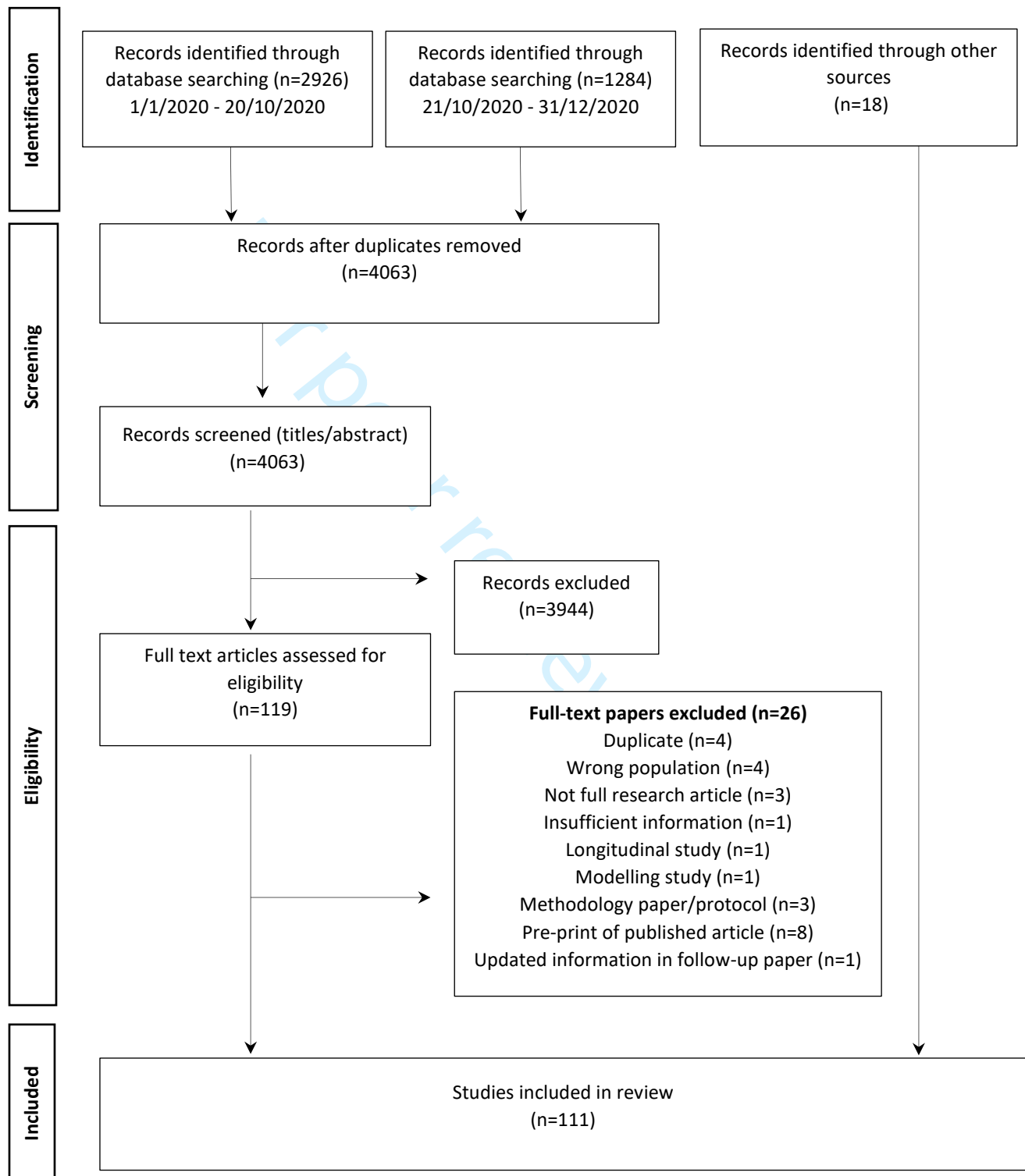
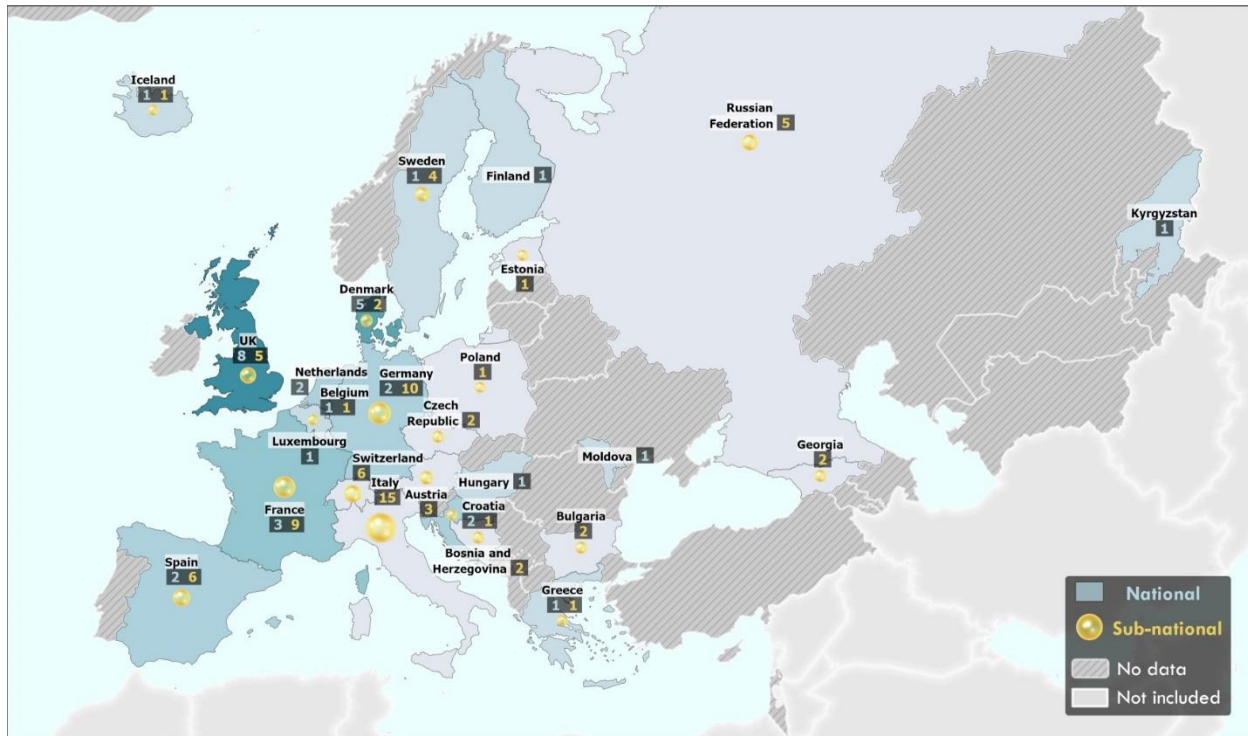


Figure 2: Geographical distribution of SARS-CoV-2 seroprevalence studies published in the WHO European Region between 1 Jan – 31 Dec 2020

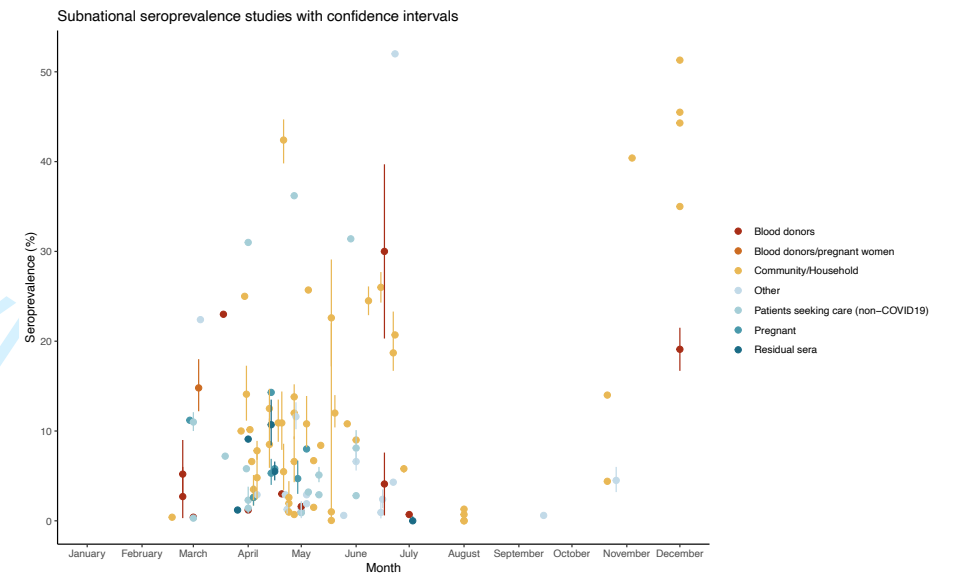
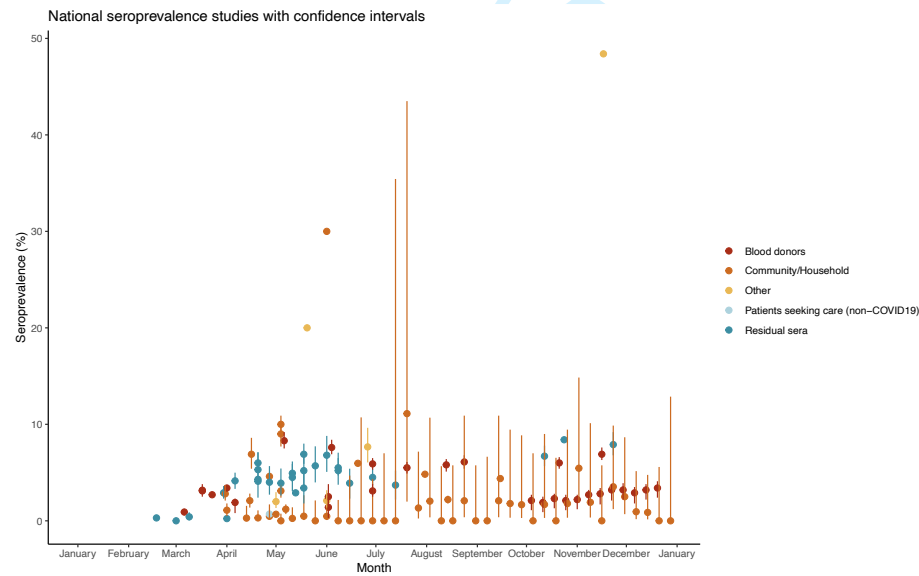


Countries with national-level seroprevalence studies are reported in blue (shade of blue reflects the number of studies conducted in the country/territory). Subnational-level seroprevalence studies are reported as a yellow circle (Size of circle reflects number of subnational studies conducted in the country/territory). Number of studies are listed in boxes under name. Countries with not studies are coloured in grey. The designations employed and the presentation of this material do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers and boundaries. Dotted and dashed lines on maps represent approximate locations for which there may not yet be full agreement.

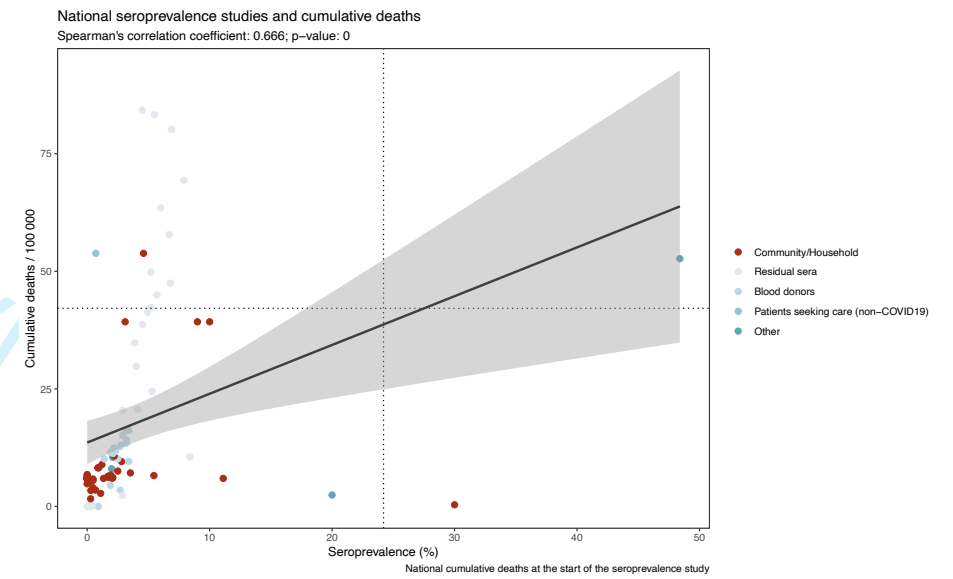
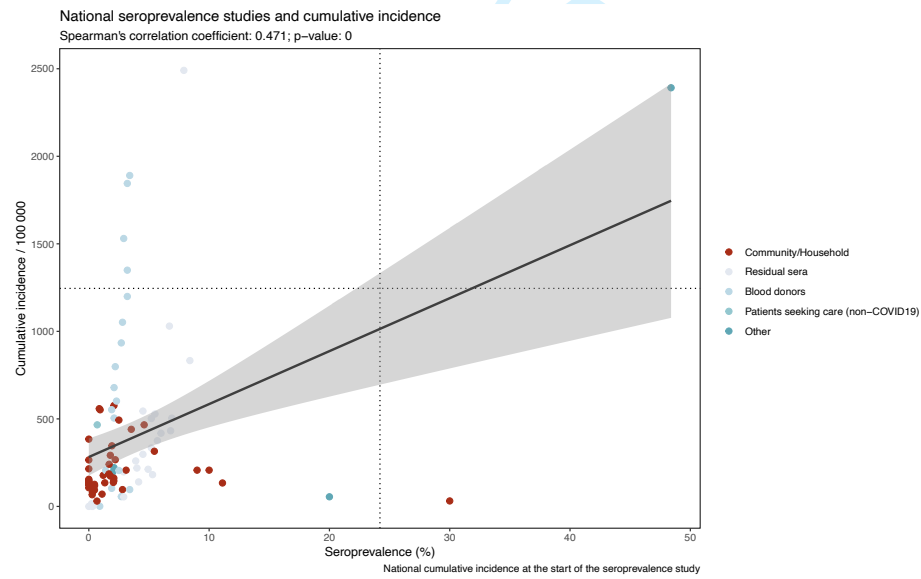
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Supplementary Material

S1 Supplementary Methods

S1.1 Search strategy and selection criteria

We searched the WHO “COVID-19 Global literature on coronavirus disease” database (MEDLINE, EMBASE and the pre-print servers medRxiv and bioRxiv) (100) using search terms that included a range of criteria relating to seroprevalence surveys. The search terms and inclusion and exclusion criteria are described below (Table S1).

S1.2 Search terms

ti:sero\$urv* or ti:serosurv* or ti:seroepidemiolog* or ti:sero\$epidemiolog* or ti:serolog* or ti:seropositiv* or ti:seropositiv* or ti:serosurveillance or ti:sero\$surveillance or ti:seroprevalence or ti:sero\$prevalence or ti:antibody or ti:antibodies or ti:immunity or ti:immunoglobulin OR ab:sero\$urv* or ab:serosurv* or ab:seroepidemiolog* or ab:sero\$epidemiolog* or ab:serolog* or ab:seropositiv* or ab:sero\$positiv* or ab:serosurveillance or ab:sero\$surveillance or ab:seroprevalence or ab:sero\$prevalence

Table S1 Inclusion and exclusion criteria

Characteristics	Inclusion criteria	Exclusion criteria
Type of evidence	Published or unpublished scientific literature	Media reports (e.g. news items and press releases), reviews, assessed performance of a test, protocols
	Completed or ongoing serosurveys	Unrelated to seroprevalence
	Report seroprevalence estimates from one or multiple time points	
	Cross-sectional and cohort study designs	Case-control studies, case reports or reviews
Population	Studies of human participants, any age	Studies of non-human participants (i.e. animal studies)
	Population groups considered to be representative of the general population	Population groups considered to be unrepresentative of the general population as they had higher risk of infection (e.g. healthcare workers and other high-risk groups).
		Studies only of individuals with suspected (e.g. respiratory symptoms) or confirmed SARS-CoV-2 (RT-PCR laboratory confirmation)
Geographical location	WHO European region	Outside of WHO European Region
Languages	Any language	N/A

Table S2: Description of the quality assessment criteria used

Risk of bias criteria	Risk of bias assessment	Risk of bias scoring
Sampling frame: Representative of general population?	Poor (e.g hospital admissions, GP visits, pregnant women, employees)	0
	Weak (eg. blood donors)	1
	Good (e.g household sampling)	2
Sampling frame: Age profile included?	Does not cover those in target population (e.g study of 'all ages' excludes elderly or children)	0
	Study includes all those in target population	1
	Includes all ages (including children)	2
Sampling method: Were study participants sampled appropriate?	Non-random/non-exhaustive (including convenience sampling)	0
	Exhaustive	1
	Random	2
Sample size: Is sample size calculation described in methods?	Unclear	0
	Yes	1
Sample size: Was the sample size adequate?	If at least 300 samples in the study then adequate OR if at least 100 samples per age group (if stratified by age)	1
	If NONE of above OR no mention in methods/unclear	0
Test method: Use of more than one assays/test?	Yes	1
	No	0
Test method 1: Are tests sufficiently accurate? (no clinical validation)	Sensitivity/specificity acceptable* (i.e ELISA: Sn \geq 95%, Sp $>$ 97% OR POCT: Sn \geq 90%, Sp $>$ 97%)	1
	Sensitivity/specificity not acceptable (i.e ELISA: Sn $<$ 95%, Sp $<$ 97% OR POCT: Sn $<$ 90%, Sp $<$ 97%)	0
Test method 2: Use of commercial tests with clinical validation?	Sensitivity/specificity acceptable* (i.e ELISA: Sn \geq 95%, Sp $>$ 97% OR POCT: Sn \geq 90%, Sp $>$ 97%)	2
	Sensitivity/specificity not acceptable (i.e ELISA: Sn $<$ 95%, Sp $<$ 97% OR POCT: Sn $<$ 90%, Sp $<$ 97%)	1
Test method 3: Use of in-house assay	Sensitivity/specificity acceptable* (i.e ELISA: Sn \geq 95%, Sp $>$ 97% OR POCT: Sn \geq 90%, Sp $>$ 97%)	2
	Sensitivity/specificity not acceptable (i.e ELISA: Sn $<$ 95%, Sp $<$ 97% OR POCT: Sn $<$ 90%, Sp $<$ 97%)	1
	No results reported	0
Data analysis: Were the results adjusted according to sensitivity/specificity of the serological test?	Yes and Confidence intervals presented	2
	Yes but no Confidence intervals presented	1
	No/Unclear	0
Overall risk of bias	High risk of bias	1-3
	Moderate risk of bias	4-6
	Low-risk bias	$>$6

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3 **S2 Supplementary Tables and Figures**
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6 **Supplementary Table S1 Inclusion and exclusion criteria**
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8 **Supplementary Table S2: Description of the quality assessment criteria used**
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10 **Supplementary Table S3: Characteristics of eligible seroprevalence studies**
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13 See PDF file attached separately
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15 **Supplementary figure S1 Forest plot of the seroprevalence of SARS-CoV-2 antibodies in**
16 **Community/Household samples with corresponding 95% confidence intervals in WHO**
17 **European Region (1/1/2020-31/12/2020)**
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22 **Supplementary figure S2: Forest plot of the seroprevalence of SARS-CoV-2 antibodies in (Top**
23 **to bottom, Left to Right) a) Residual sera b) Blood donors c) Pregnant or Parturient women d)**
24 **Patients seeking care (non-COVID) and e) Other populations**
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29 **Supplementary figure S3 Time point of conducted sero-epidemiology studies in relation to**
30 **country epidemic activity**
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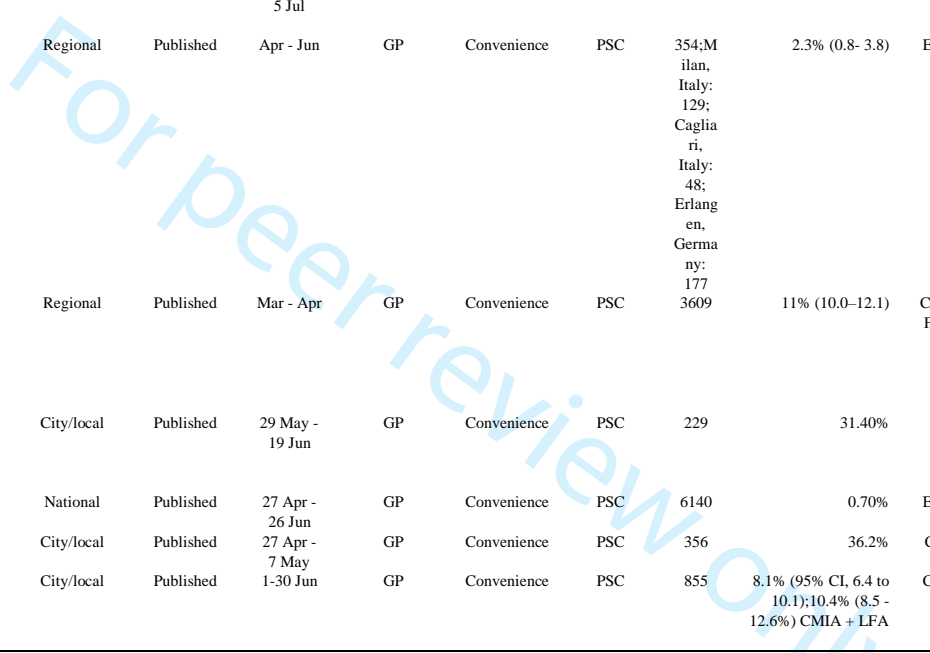
Author	Country	Study Location	Region	WHO UNITY	Geographic location	Publication	Study period	Study population	Sample method	Sampling frame	No.	Sero-positivity (%)	Method	Assay	Antibody	Sn (%)	Sp (%)	Score	Risk of bias	
Household and community																				
1 2 3	Knabl (16)	Austria	Tyrol, Ischgl	EU/EEA	Yes	City/local	Published^	21-27 Apr	GP	Random	HH/C	1473	42.4% (39.8 - 44.7%)	ELISA; CLIA	EUROIMMUN; Abbott laboratories;	Anti-S; IgA;IgG; anti-N IgG	NR	NR	8	Low
4 5 6 7 8	Wagner (17)	Austria	Vienna	EU/EEA	No	City/local	Pre-print	12-17 Apr	GP	Convenience	HH/C	1655	10.15%	ELISA; ELISA; CLIA; MN	EUROIMMUN; Beijing Wantai Biological Pharmacy Enterprise; EUROIMMUN; Roche Diagnostics; In-house;	IgA;IgG; IgM, total Abs;IgG; Total Abs;NT-Abs	NR	NR	3	High
9 10	Ladage (18)	Austria	Weißkirchen/Wachau	EU/EEA	No	City/local	Published	1-15 Jun	GP	Convenience	HH/C	835	ELISA: IgG 8.5%; IgA 9.0%;	ELISA;	EUROIMMUN	IgA;IgG	NR	NR	5	Medium
11 12 13	Boey (19)	Belgium	Pelt; Alken	EU/EEA	No	Regional	Published^	21 Sept - 6 Oct	GP	Random	HH/C	362	4.4% (low exposed - Pelt); 14.4% (high exposed - Alken)	ELISA;	Beijing Wantai Biological Pharmacy Enterprise; EUROIMMUN	Total Abs;	99.6%	NR	4	Medium
14 15	Bokonjic (20)	Bosnia and Herzegovina	Republika Srbska	non-EU/EEA	Yes	Regional	Unpublished	4 Nov - 16 Dec	GP	Random	HH/C	1855	40.4%	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	Total Abs;	94%	100%	N/A	N/A
16 17	Kunchev and Stoitsova	Bulgaria	Plovdiv	EU/EEA	Yes	City/local	Direct submission	18-May-13 Jun	GP	Random	HH/C	553	1.08% (0.5-2.35); 0.04% (0-0.12) [§]	ELISA;	EUROIMMUN	IgG; IgA	NR	NR	N/A	N/A
18 19 20	Statens Serum Institute (21)	Denmark	Copenhagen; Aarhus; Aalborg; Næstved; Odense	EU/EEA	Yes	National	Report	Apr	GP	Random	HH/C	1071	1.1% (0.5-1.8)	ELISA	NR	NR	NR	NR	6	Medium
21 22 23	Statens Serum Institute (22) (23)	Denmark	Copenhagen; Aarhus; Aalborg; Næstved; Odense	EU/EEA	Yes	National	Report	7 May - 9 Jun; 14 Aug - 1 Oct	GP	Random	HH/C	2444; 18000	1,2 (0,7-1,7);2,2 (1,8 -2,6)	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	NR	NR	NR	9	Low
24 25	Petersen (24)	Denmark	Faroe Islands	EU/EEA	Yes	Regional	Published	27 Apr - 1 May	GP	Random	HH/C	1500	0.7% [§]	ELISA	Beijing Wantai Biological Pharmacy Enterprise	IgM; IgG	94%	100%	9	Low
26 27 28 29	Jõgi (25)	Estonia	Tallinn; Saaremaa	EU/EEA	No	Regional	Pre-print	8 May - 31 Jul	GP	Random	HH/C	Total 1960; 1006; 954;	Tallinn: 1.5% § ; Saaremaa: 6.7% §	CMIA; CLIA; LIPS; LFA;	Abbott Laboratories; DiaSorin Liaison; In-house; Biosensor	IgG; IgG; NA; IgM/IgG	92.7%	99.9%	12	Low
30 31	THL (26)	Finland		EU/EEA	No	National	Report	13 Apr - 28 Dec	GP	Random	HH/C	4863	*see report	FMIA	In-house	NR	NR	NR	7	Low
32 33 34 35 36 37 38 39	Carrat (27)	France	Ile-de-France; Grand Est; Nouvelle-Aquitaine;	EU/EEA	Yes	National	Pre-print	4 May - 23 Jun	GP	Random	HH/C	14628	Ile-de- France: 10%; Grand Est: 9.0% ; Nouvelle-Aquitaine: 3.1%;	ELISA; MN	EUROIMMUN; In-house	IgG	ELISA - S=97.7%; ELISA - NP=50.4%; SN=41.4%	ELISA - S=97.7%; ELISA - NP=99.5%; SN=99.5%	9	Low
40 41 42	Zakhashvili (28)	Georgia	Martvili; Kobuleti; Borjomi; Khelvachauri	non-EU/EEA	Yes	National	Unpublished	1 - 14 Aug 2020; 1 - 14 Dec 2020	GP	Random	HH/C	1218; 1219	August: 0%;0%:0.7%;1.3% December:44.3%;35 %;45.5%;51.3%;	ELISA; CMIA	Wantai Total Ab ELISA; Roche Diagnostics	Total Abs; Total Abs;	NR	NR	N/A	N/A
43 44 45 46 47	Tsertsvadze (29)	Georgia	Tblisi	non-EU/EEA	No	City/local	Pre-print	18-27 May	GP	Convenience	HH/C	1068	1.02% (0.38-2.18) §	LFA	Zhejiang Orient Gene Biotech	IgG	93.1%	99.2%	6	Medium
	Aziz (30)	Germany	Bonn	EU/EEA	Yes; No	City/local	Published^	24 Apr - 30 Jun	GP	Convenience	HH/C; Voluntary	Group 1: 4771; Group 2: 360;	0.97% (0.72-1.30%); 1.94% (0.84-4.42%)	ELISA	EUROIMMUN	IgG	NR	NR	7	Low

16	Streck (51)	Germany	Heinsberg	EU/EEA	Yes	City/local	Published^	31 Mar - 4 Jun	GP	Random	HH/C	919	14.1% (11.15% - 17.27%) §	ELISA	EUROIMMUN;	IgA; IgG	90.9%	99.1%	10	Low
17	Santos-Höivener (32)	Germany	Kupferzell	EU/EEA	Yes	City/local	Published	20 May - 9 Jun	GP	Random	HH/C	2203	12% (10.4-14%) §	ELISA	EUROIMMUN;	IgG	88.3%	99.2%	10	Low
18	Weis (33)	Germany	Thuringia	EU/EEA	No	Regional	Published	12-22 May	GP	Random	HH/C	626	8.4%	ELISA; ELISA; CLIA; CMIA; CLIA; CLIA	EUROIMMUN; Epitope Diagnostics Inc. DiaSorin; Abbott Laboratories; Roche Diagnostics; Snibe Co.;	IgG	NR	NR	10	Low
19	Merkely (34)	Hungary		EU/EEA	Yes	National	Published	1-16 May	GP	Random	HH/C	10474	0.68 (0.5-0.86)	CMIA	Abbott Laboratories	IgG	NR	NR	6	Medium
20	Pagani (35)	Italy	Castiglione D'Adda	EU/EEA	Yes	City/local	Published	18 May - 7 Jun	GP	Random	HH/C	509	22.6% (17.2-29.1)	CMIA; LFA	Abbott Laboratories; Prima Lab	IgG	NR	NR	9	Low
21	Stefanelli (36)	Italy	Trento	EU/EEA	Yes	Regional	Published	5-15 May	GP	Random	HH/C	6075	25.7% §	CMIA	Abbott Laboratories	IgG	99.60%	100%	10	Low
22	Guerrero (37)	Italy	Verona	EU/EEA	Yes	City/local	Published	24 Apr - 8 May	GP	Random	HH/C	1515	2.6%	CMIA	Abbott Laboratories	IgG	81.80%	99.30%	8	Low
23	Cito (38)	Italy	Villa Caldari, Abruzzo region	EU/EEA	Yes	Regional	Published	18-19 Apr	GP	Random	HH/C	687	10.9% (8.8-13.5%)	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	Total Abs	93%	100%	9	Low
24	Zuridin & Tatyana (39)	Kyrgyzstan	Bishkek City; Osh City; Chui; Osh; Jalal-Abad; Batken; Issyk-Kul; Naryn; Talas	non-EU/EEA	Yes	National	Unpublished	4 Jul - 12 Aug	GP	Random	HH/C	4780	32.5%	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	Total Abs	95%	100%	N/A	N/A
25	Snoeck (40)	Luxembourg		EU/EEA	Yes	National	Pre-print	15 Apr - 5 May	GP	Random	HH/C	1862	IgG: 2.09% (1.37-2.82) § IgA: 11.07% (9.54-12.60) §	ELISA	EUROIMMUN;	IgG; IgA;	85.7%; 92.2%;	97.8%; 89.2%;	8	Low
26	Vos (41)	Netherlands		EU/EEA	No	National	Published	31 Mar - 11 May	GP	Random	HH/C	3207	2.8% (2.1 - 3.7) §	Fluorescent bead-based multiple ximmunoassay	In-house	IgG	84.40%	NR	10	Low
27	Popova (42)	Russian Federation	Irkutsk Region	non-EU/EEA	No	Regional	Published	28 Jun - 19 Jul	GP	Random	HH/C	2674	5.8% (5.3- 6.2)	ELISA	In house	IgG	NR	NR	8	Low
28	Popova (43)	Russian Federation	Leningrad	non-EU/EEA	No	Regional	Published	23 Jun - 26 Jun	GP	Random	HH/C	3130	20.70%	ELISA	In house	IgG	NR	NR	8	Low
29	Barchuk (44)	Russian Federation	Saint-Petersburg	non-EU/EEA	Yes	City/local	Published^	27 May - 26 Jun	GP	Random	HH/C	1038	9.0% CMIA; 10.8% ELISA §	ELISA; CMIA	CoronaPass; Abbott Laboratories	IgG; Total Abs	98.7%; 100%	100%; 99.6%	12	Low
30	Popova (45)	Russian Federation	Saint-Petersburg	non-EU/EEA	No	City/local	Published	15 Jun - 20 Jun	GP	Random	HH/C	2713	26% (24.3-27.7)	ELISA	In house	IgG	NR	NR	8	Low
31	Popova (46)	Russian Federation	Tyunmen region	non-EU/EEA	No	Regional	Published	8 - 21 Jun	GP	Random	HH/C	2758	24.5% (22.9- 26.1)	ELISA	In house	IgG	NR	NR	8	Low
32	Pollan (47)	Spain		EU/EEA	Yes	National	Published	27 Apr - 11 Ma	GP	Random	HH/C	51958	4-6% (4.3-5.0) §	CLIA;LFA	Abbott Laboratories; Zhejiang Orient Gene Biotech	IgG	89.7%	100%	12	Low
33	Public Health Agency of Sweden (48)	Sweden	Rinkeby-Kista district, Stockholm	EU/EEA	Yes	City/local	Report	22 Jun - 24 Jun	GP	Random	HH/C	538	18,7% (95% CI 14,8-23,3)	CMIA; CLIA;LIPS; LFA; ELISA	Abbott Laboratories; DiaSorin Liaison	IgG	100	99,6	11	Low
34	Roxhed (49)	Sweden	Stockholm	EU/EEA	Yes	City/local	Published^	mid-Apr - mid-May	GP	Random	HH/C	878	12.5% (95% CI: 10.3%-14.7%)	ELISA	In house	IgM; IgG	100%	98%	7	Low
35	Richard (50)	Switzerland	Canton of Geneva	non-EU/EEA	Yes	Regional	Pre-print	6 Apr - 30 Jun	GP	Random	HH/C	8344	7.8% (6.8-8.9)	ELISA	EUROIMMUN	IgG	93%	100%	10	Low
36	Bi (51)	Switzerland	Geneva	non-EU/EEA	Yes	City/local	Pre-print	3 Apr - 30 Jun	GP	Random	HH/C	4354	6.6%	ELISA	EUROIMMUN	IgG	93%	99%	9	Low
37	Stringhini (52)	Switzerland	Geneva	non-EU/EEA	Yes	City/local	Published	6 April - 9 May	GP	Random	HH/C	2766	1stweek: 4-8% (2.4-8-0); 2nd week: 8-5% (5.9-11.4); 3rd week: 10-9% (7.9-14.4);	ELISA	EUROIMMUN	IgG	93%	100%	9	Low

1	Ward (53)	United Kingdom	England	non-EU/EEA	No	National	Pre-print	20 Jun - 13 Jul; 31 Jul - 13 Aug; 15 Sept - 28 Sept	GP	Random	HH/C	99908; 10582 9;1593 67	5.96 (5.78–6.14); 4.83 (4.67–5.00); 4.38 (4.25–4.51) §	LFA	Fortress Diagnostics	IgG	84.4%	98.6%	9	Low	
2																					
3																					
4	Wells (54)	United Kingdom	London; South East England	non-EU/EEA	Yes	Regional	Published	27 Apr - 2 Jun	GP	Convenience	HH/C	431	12% (9.1–15.2)	CLIA;C MIA	Abbott Laboratories; Roche Diagnostics	IgM; IgG	90%	100%	6	Medium	
5																					
6	Residual sera																				
7	Herzog (55)	Belgium	Wallonia; Flanders; Brussels	EU/EEA	Yes	National	Pre-print	30 Mar - 5 Apr; 20 Apr - 26 Apr; 18 May - 25 May; 8 Jun - 13 Jun; 29 Jun - 4 Jul	GP	Convenience	RS	Total: 15529; 3910;3 397;32 42;296 0;3023 ;	2.9% (2.3–3.6%); 6.0% (5.1–7.1%); 6.9% (5.9–8.0%); 5.5% (4.7–6.5%); 4.5% (3.7–5.4%)	ELISA	EUROIMMUN;	IgG	64.5 - 87.8%	99.20 %	5	Medium	
8																					
9																					
10																					
11																					
12																					
13	Tsaneva-Damyanova (56)	Bulgaria	Varna city; North East Bulgaria	EU/EEA	Yes	Regional	Published	26 Mar - 20 Apr	GP	Convenience	RS	586	4.8% overall; 1.0% IgM; 1.2% IgG; 2.6% IgM and IgG	LFA	Zhejiang Orient Gene Biotech	IgM; IgG	85%	96%	4	Medium	
14																					
15	Bloomfield (57)	Czech Republic	Prague	EU/EEA	Yes	City/local	Published	3 Jul - 19 Aug	GP	Convenience	RS (Children)	200	0% (0–0.5%)	ELISA; CLIA	EUROIMMUN; Roche Diagnostics	IgA; IgG	EURO IMMUN; IgA=9 8.6%; IgG=9 4.4%; Elecsys=99.8 %;	EURO IMMUN; IgA=9 8.6%; IgG=9 9.6%; Elecsys=99.8 %;	3	High	
16																					
17																					
18																					
19																					
20																					
21	Krleza (58)	Croatia	Zagreb	EU/EEA	No	National	Published^	13 – 29 May ; 24 Oct – 23 Nov	GP	Convenience	RS (Children)	240; 308	2.9%; 8.4%	ELISA; CLIA; MN	Vircell; Roche Cobas Elecsys; In-house	NR	NR	NR	3	High	
22																					
23																					
24	Capai (59)	France	Corsica	EU/EEA	Yes	Regional	Published	16 Apr - 15 Jun	GP	Convenience	RS	1973	5.5% (4.5–6.6%) §	ELISA; MN	EUROIMMUN; In-house	IgG	NR	NR	8	Low	
25	Cohen (60)	France		EU/EEA	Yes	City/local	Pre-print	14 Apr - 12 May	GP	Convenience	RS (Children)	605	10.7% (8.4–13.5)	LFA	Biosynex BSS test	IgM; IgG	91.8%	99.2%	5	Medium	
26																					
27	Le Vu (61)	France		EU/EEA	Yes	National	Published^	9 Mar - 15 Mar; 6 Apr - 12 Apr; 11 May - 17 May;	GP	Convenience	RS	Total: 11 021;38 34;359 5;3592 ;	March:0.41% [0.05–0.88] §; April: 4.14% [3.31–4.99] §; May: 4.93% [4.02–5.89] §	LuLISA ;MN	In-house;In-house;	IgG;NT-Abs	LuLISA A N=86 %; LuLISA A S=96 %	LuLISA A =100% ; LuLISA A =100%	13	Low	
28																					
29																					
30																					
31																					
32	Bogogiannidou (62)	Greece		EU/EEA	Yes	National	Published	1 Mar - 30 Apr	GP	Convenience	RS	6586	March = 0 (0–0.23%) §; April=0.23% (0–0.48%) §	ELISA; ELISA; CMIA	EUROIMMUN; Vircell; Abbott Laboratories;	IgG	84%	99.7%	8	Low	
33																					
34	Gudbjartsson (63)	Iceland		EU/EEA	Yes	Regional; National	Published	18 Feb - 9 Mar	GP	Convenience	RS	470; 24115	0%; RS: 0.30% (0.2 - 0.4) §; Reykjavik: 0.4% (0.3 - 0.6)	ELISA; ELISA; ELISA; CLIA	EUROIMMUN; EDI/Eagle;Roche Diagnostics	IgA; IgM; IgG	NR	99.80 %	9	Low	
35																					
36																					
37	Public Health Agency of Sweden (64, 65)	Sweden	Jämtland; Härjedalen; Jönköping; Kalmar; Skåne; Stockholm; Uppsala; Västerbotten; Västra Götaland;Örebro	EU/EEA	No	National	Report	20 Apr to 12 Jun; 12 Oct to 23 Oct; Nov 23 to 4 Dec	GP	Convenience	RS	4500 per collection period	*see report	NR	Sci Life Lab / KTH	NR	98.9	99.4	6	Low	
38																					
39																					
40																					
41																					
42																					
43	Posfay-Barbe (66)	Switzerland	Geneva	non-EU/EEA	No	City/local	Published	1–30 Apr	GP	Convenience	RS	208	ELISA: 9.1%; LFA: 12.5%	ELISA; LFA	EUROIMMUN	IgG	NR; 88.9%	NR; 94.7%	2	High	
44																					
45																					
46																					
47																					

Page	Author	Country	Region	EU/EEA	Yes	National	Published	Date	GP	Convenience	RS	Value	CI	Method	Company	Ab	Sp	Se	PPV	NPV	LR	MD
51	Dickson (67)	United Kingdom	Scotland	non-EU/EEA	Yes	National	Published	20 Apr - 15 Jun	GP	Convenience	RS	4751	4.3% (4.2-4.5)	CLIA	DiaSorin Liaison	IgG	87.5%	98.6%	3	High		
52	Public Health Scotland (68)	United Kingdom	Scotland	EU/EEA	Yes	National	Report	20 Apr - 17 May; 18 May - 14 Jun; 15 Jun - 12 Jul; 13 Jul - 9 Aug;	GP	Convenience	RS	2039; 172; 2709; 2882	4.1% (2.4%, 5.7%); 3.4% (1.8%, 5.0%); 3.9% (2.3%, 5.4%); 3.7% (2.2%, 5.2%)	CMIA	DiaSorin Liaison	NR	NR	NR	4	Medium		
53	Musa (69)	Bosnia and Herzegovina	Federation of Bosnia and Herzegovina	non-EU/EEA	Yes	Regional	Unpublished	1 Nov - 7 Dec	BD	Convenience	BD	1015	19.1% (16.7-21.5)	CMIA	Abbott Laboratories	Total Abs;	NR	NR	N/A	N/A		
54	Pedersen (70)	Denmark	Danish Capital Region; Zealand Region; Central Denmark Region	EU/EEA	Yes	National	Published	2 Jun - 19 Jun	BD	Convenience	BD	Total: 2311; 17-69yrs: 1110; >70yrs: 1201	17-69yrs: 2.5 (1.3-3.8) [§] ; >70yrs: 1.4 (0.3-2.5) [§]	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	Total Abs;	96.7% (92.4-98.6)	99.5% (98.7-99.8)	7	Low		
55	Erikstrup (71)	Denmark		EU/EEA	Yes	National	Published [^]	6 Apr - 3 May	BD	Random	BD	20 640	2.0% (95% CI, 1.8-2.2%); 1.9% (95% CI, 1.8-2.3) [§]	LFA	Livzon Diagnostics Inc	IgM; IgG	82.6%	99.5%	7	Low		
56	Bloddonor (72)	Denmark		EU/EEA	No	National	Report	5 Oct - 31 Dec	BD	Convenience	BD	71883	*see report	LFA	Livzon	NR	NR	NR	4	Medium		
57	Gallian (73)	France	Haut-Rhin departmental area [DA]; Seine-Saint-Denis DA; Bouches-du-Rhône DA; Oise DA; Lille	EU/EEA	No	National	Published	23 Mar - 5 Apr	BD	Convenience	BD	998	2.71%	MN	In-house	NT-Abs	NR	100%	6	Medium		
58	Grzelak (74)	France		EU/EEA	No	City/local	Published	20-24 Mar	BD	Convenience	BD	200	3%	ELISA; LIPS; MN	In-house; In-house; In-house;	IgA; IgG; IgM	NR	NR	3	High		
59	Fischer (75)	Germany	Hesse; Lower Saxony; North Rhine-Westphalia	EU/EEA	Yes	National	Published	Mar - Jun	BD	Convenience	BD	3186	0.91% (0.58-1.24)	ELISA; CLIA; CMIA	EUROIMMUN; Diasorin Liaison; Abbott Laboratories	IgG	65%	99-100%	4	Medium		
60	Runkel (76)	Germany	Southwest	EU/EEA	Yes	Regional	Published	Mar - Jun	BD	Convenience	BD	3754	0.40%	ELISA; CLIA; CMIA	Epitope Diagnostics; Immundiagnostik AG; Abbott Architect; Roche Diagnostics	IgG	NR	Abbott =99.6%; DK5000=99.00-99.1%; EDI=96.4%	7	Low		
61	Percivalle (77)	Italy	Lombardy	EU/EEA	Yes	City/local	Published	18 Mar - 6 Apr	BD	Convenience	BD	390	23%	MN	In-house	NT-Abs	95%	100%	6	Medium		
62	Fiore (78)	Italy	South East	EU/EEA	No	Regional	Published	1-31 May	BD	Convenience	BD	904	0.99%	CLIA	Snibe Co., Ltd.	IgM; IgG	IgM=78.65%; IgG=91.21%	IgM=97.5%; IgG=97.3%	4	Medium		
63	Valenti (79)	Italy	Milan	EU/EEA	Yes	City/local	Pre-print	24 Feb - 8 Apr	BD	Convenience	BD	789	February/March: 2.7% (95% CI, 0.3-6.0%); March/April: 5.2% (2.4-9.0) [§]	LFA	Prima Lab	IgM; IgG	IgM=68%; IgG=100%	99.20%	10	Low		
64	Slot (80)	Netherlands		EU/EEA	Yes	National	Published	1-15 Apr	BD	Convenience	BD	7361	3.40%	ELISA	Beijing Wantai Biological Pharmacy Enterprise;	IgA; IgM; IgG	100%	99.1-100%	5	Medium		
65	Lundkvist (81)	Sweden	Djurgårdsstaden and Tensta (Stockholm)	EU/EEA	Yes	City/local	Published	17-18 Jun	BD	Random	BD	213	Djurgårdsstaden: 4.1% (0.6-7.6%); Tensta: 30.0% (20.3-39.7%)	LFA	Zhejiang Orient Gene Biotech	IgM; IgG	IgM=100%; IgG=100%	IgM=100%; IgG=95.5%	6	Medium		
66	Public Health England (82-87)	United Kingdom	England	non-EU/EEA	Yes	National	Report	23 Mar - 3 Dec	BD	Convenience	BD	1000 sample s/week /region	*see report	ELISA	EUROIMMUN	IgG	79%	99%	4	Medium		
67	Thompson (88)	United Kingdom	Scotland	non-EU/EEA	Yes	National	Published	17 Mar - 18 May	BD	Convenience	BD	3500	3.17%	CLIA; CMIA	Abbott Laboratories; Roche Diagnostics	IgM; IgG	94.1%	100%	8	Low		

68	Public Health Scotland (68)	United Kingdom	Scotland	EU/EEA	Yes	National	Report	29 Jun - 9 Aug	BD	Convenience	BD	3220	3.1% (2.5%, 3.8%)	NR	NR	NR	NR	NR	NR	NR	NR	
Patients seeking healthcare (non-COVID-19)																						
69	Fogel (89)	France	Paris	EU/EEA	No	City/local	Published	1 Jun - 31 Aug	GP	Convenience	PSC	249	2.8%	CMIA	Abbott Laboratories	IgG	NR	NR	NR	NR	2	High
70	Choi (90)	Germany	Berlin	EU/EEA	No	City/local	Published	19 Mar - 19 May	GP	Convenience	PSC	223	7.20%	ELISA; IFIT; PRNT	EUROIMMUN; In house; In house	IgA; IgG	NR	NR	NR	NR	1	High
71	Rauber (91)	Germany	Heidelberg	EU/EEA	No	City/local	Published	5 May - 8 Jun	GP	Convenience	PSC	219	3.2%	ELISA	EUROIMMUN	IgG	94.6%	99.8%	NR	NR	1	High
72	Zambelli (92)	Italy	Bergamo	EU/EEA	No	City/local	Published	1-30 Apr	GP	Convenience	PSC	560	31%	LFA	Moers	IgM; IgG	NR	NR	NR	NR	2	High
73	Medas (93)	Italy	Cagliari	EU/EEA	No	City/local	Published	31 Mar - 30 Jun	GP	Convenience	PSC	86	5.8%	CLIA	Snibe Co., Ltd	IgM; IgG	NR	NR	NR	NR	1	High
74	Capasso (94)	Italy	Campania Region	EU/EEA	No	Regional	Published	11 May - 15 Jun	GP	Convenience	PSC	310	2.90%	LFA	Shanghai Kehua LFAI	IgM; IgG	66%	96.60%	NR	NR	4	Medium
75	Cento (95)	Italy	Milan	EU/EEA	No	City/local	Published	11 May - 5 Jul	GP	Convenience	PSC	2753	5.1% (4.3%-6.0%)	CLIA; CLIA	Abbott Laboratories DiaSorin Liaison	IgG	84.2-100%	99.6-100%	NR	NR	4	Medium
76	Berte (96)	Italy; Germany	Milan and Cagliari; Erlangen	EU/EEA	No	Regional	Published	Apr - Jun	GP	Convenience	PSC	354; Milan, Italy: 129; Cagliari, Italy: 48; Erlangen, Germany: 177	2.3% (0.8- 3.8)	ELISA	In house	IgA; IgG	IgA=7.14%; IgG=9.8%; 7.64%	IgA=9.8%; IgG=9.5.2%	NR	NR	4	Medium
77	Vena (97)	Italy	Liguria; Lombardia	EU/EEA	No	Regional	Published	Mar - Apr	GP	Convenience	PSC	3609	11% (10.0-12.1)	CLIA; LFA; LFA	MaglumiTM; Realy tech; Biosynex BSS	IgM; IgG	IgM=7.8.6-100%; IgG=9.0.6-100%	IgM=8.7.5%; IgG=9.0.6-100%	NR	NR	4	Medium
78	Cabezón-Gutiérrez (98)	Spain	Madrid	EU/EEA	No	City/local	Published	29 May - 19 Jun	GP	Convenience	PSC	229	31.40%	LFA	Hangzhou Testsea Biotechnology	IgM; IgG	IgM=8.8%; IgG=9.6%	IgM=1.00%; IgG=1.00%	NR	NR	4	Medium
79	Prados (99)	Spain		EU/EEA	No	National	Published	27 Apr - 26 Jun	GP	Convenience	PSC	6140	0.70%	ELISA	EDI Epitope Diagnostics	IgM; IgG	NR	NR	NR	NR	3	High
80	Clarke (100)	United Kingdom	London	non-EU/EEA	No	City/local	Published	27 Apr - 7 May	GP	Convenience	PSC	356	36.2%	CMIA	Abbott Laboratories	IgG	NR	NR	NR	NR	3	High
81	Prendecki (101)	United Kingdom	London	non-EU/EEA	No	City/local	Published	1-30 Jun	GP	Convenience	PSC	855	8.1% (95% CI, 6.4 to 10.1); 10.4% (8.5 - 12.6%)	CMIA; LFA	Abbott Laboratories; Fortress Diagnostics	IgG	90.6%; 96.5%	NR	NR	NR	4	Medium
Pregnant or parturient women																						
82	Egerup (102)	Denmark	Copenhagen	EU/EEA	No	City/local	Published	4 Apr - 3 Jul	GP	Convenience	Pregnant or parturient women; Partners: Newborns	Total: 3707; Pregnant or parturient women: 2.6% (1.7-4.0) [§] ; Partners: 3.5% (2.3 - 5.1) [§] Newborns: 1.4% [§]	CLIA	Shenzhen Yhlo Biotech	IgM; IgG	IgM=4.2%; IgG=9.4%	IgM=9.9.7%; IgG=9.9.3%	NR	NR	7	Low	
83	Mattern (103)	France	Paris	EU/EEA	Yes	City/local	Published	4-31 May	GP	Convenience	Pregnant or parturient women	249	8%	CMIA	Abbott Laboratories	IgG	NR	NR	NR	NR	3	High
84	Tsatsaris (104)	France	Paris	EU/EEA	Yes	City/local	Published	29 Apr - 26 Jun	GP	Convenience	Pregnant or	529	4.7% (3.0-6.7%)	CMIA	Abbott Laboratories	IgG	92.7 - 97.3 %	>99%	NR	NR	3	High



85	Cosma (105)	Italy	Turin4/6/2020	EU/EEA	No	City/local	Published	16 Apr - 4 Jun	GP	Convenience	parturient women Pregnant or	138	5.80%	CLIA;LFA;LFA	DiaSorin Liaison; Boditech;AFIAS	IgM; IgG	NR	NR	2	High
1											parturient women Pregnant or									
86	Crovetto (106)	Spain	Madrid	EU/EEA	Yes	City/local	Pre-print	14 Apr - 5 May	GP	Convenience	parturient women Pregnant or	874	14.3%	CLIA	Vircell	IgA; IgM; IgG	IgM/IgA=89%; IgG=70%	IgM/IgA=99%; IgG=89%	2	High
2											parturient women Pregnant or									
3											parturient women Pregnant or									
4											parturient women Pregnant or									
85	Villalafn(107)	Spain	Madrid	EU/EEA	No	City/local	Published	28 Feb - 10 May	GP	Convenience	Pregnant or	769	11.2%	ELISA	In house	IgG	NR	NR	2	High
5											parturient women Pregnant or									
6											parturient women Pregnant or									
7											parturient women Pregnant or									
88	Lumley (108)	United Kingdom	Oxford	non-EU/EEA	Yes	City/local	Published	14 Apr - 15 Jun	GP	Convenience	Pregnant or	1000	5.3% (4.0-6.9)	CLIA	In house	IgG	99.1%	99%	4	Medium
8											parturient women Pregnant or									
9											parturient women Pregnant or									
10											parturient women Pregnant or									
11	Krátká (109)	Czech Republic	Stratonice; Pisek	EU/EEA	No	Regional	Published	4-15 May	Other	NR	Employee s	2011	Stratonice 2.9%; Pisek 1.9%	ELISA	EUROIMMUN;	IgA; IgG	IgA=9.2%; IgG=9.4%	IgA=9.2%; IgG=9.6%	5	Medium
12											Employee s									
13											Employee s									
14	Jerkovic (110)	Croatia	Split-Dalmatia; Sibenik-Knin County	EU/EEA	No	Regional	Published	23-28 Apr	Other	Convenience	Employee s - voluntary	1494	1.27% (0.8-2.0%)	LFA	AMP Diagnostics	IgM; IgG	IgM:9.5.7%; IgG:91.8%	IgM=9.7.3%; IgG=96.4%	6	Medium
15											Employee s - voluntary									
16	Vince (111)	Croatia		EU/EEA	No	National	Pre-print	20 May - 31 Jul	Other	Convenience	Football players	305	20%	ELISA	EUROIMMUN;	IgA; IgG	NR	NR	2	High
17											Football players									
18	Anna (112)	France	Ile-de-France: Paris; Saint-Cloud; Orsay	EU/EEA	No	City/local	Published	28 Apr - 31 Jul	Other	Convenience	Employee s - voluntary	1847	11.6%	LuLISA ;MN	In-house;In-house;	IgG	NR	98%	6	Medium
19											Employee s - voluntary									
20	Fontanet (113)	France	Oise	EU/EEA	No	City/local	Published^	30 Mar - 4Apr; 28 Mar - 30 Apr	Other	Convenience	HH/C samples; ;High school; Primary school	664 1340	25%; 10%	ELISA; S-flow; LIPS;	In-house;In-house; In-house	IgG	99.4%	>99%	8	Low
21											HH/C samples; ;High school; Primary school									
22											HH/C samples; ;High school; Primary school									
23	Roederer (114)	France	Paris	EU/EEA	No	City/local	Published^	23 Jun - 2 Jul	Other	Convenience	Persons experiencing homelessness	818	52%	LuLISA * ;MN	In-house	IgG	NR	97-100%	9	Low
24											Persons experiencing homelessness									
25											Persons experiencing homelessness									
26	Krähling (115)	Germany	Frankfurt am Main	EU/EEA	No	City/local	Pre-print	6-14 Apr	Other	Convenience	Employee s	998	2.90%	ELISA	In-house;	IgG	87.2-100%	99.2%	4	Medium
27											Employee s									
28	Mack (116)	Germany		EU/EEA	No	National	Published	May; June	Other	Convenience	Professional football teams	1184	May: 1.99% (1.33-2.97); June: 2.09% (1.37-3.17); 48.4%	ELISA; CLIA	EUROIMMUN;Roche Diagnostics	IgG	NR	NR	3	High
29											Professional football teams									
30	Ceban (117)	Republic of Moldova		non EU/EEA	Yes	National	Unpublished	17 Nov 2020 - 15 Jan 2021	Other	Random	Hospital visitors	5656		ELISA	Beijing Wantai Biological Pharmacy Enterprise	Total Ab	NR	NR	N/A	N/A
31											Hospital visitors									
32	Gujski (118)	Poland	Mazowieckie Province	EU/EEA	No	Regional	Published	22 Jun - 8 Jul	Other	Random	Employee s	5082	4.30%	ELISA	Vircell	IgA; IgM; IgG	65% - 97%	82% - 96%	3	High
33											Employee s									
34	Pérez-García (119)	Spain	Madrid	EU/EEA	No	City/local	Published	5 Mar - 30 May	Other	Convenience	Employee s	2963	22.40%	LFA	AllTest Biotech	IgM; IgG	88%	100%	4	Medium
35											Employee s									
105	Ulyte (120)	Switzerland	Canton of Zurich	non-EU/EEA	No	Regional	Published^	16 Jun - 9 Jul; 26 Oct - 19 Nov	Other	Random	School children	5155; 2603; 2552	7.8% (6.2% to 9.5%); 2.4% (1.4-3.5); 4.5% (3.2-6.0);	ELISA	In-house	IgA; IgM; IgG	93.3-94.3%	99-99.6%	6	Medium
36											School children									
37											School children									
101	Roarty (121)	United Kingdom	Belfast; Cardiff; Glasgow; London; Manchester	non-EU/EEA	No	National	Published	26 Jun - 15 Aug	Other	Convenience	Children of employee s	849	7.66% (6.05-9.64)	CLIA; CLIA	Elecsys Roche; DiaSorin Liaison	IgG	84%; 64%	100%; 98%	4	Medium
38											Children of employee s									
39											Children of employee s									
102	Waterfield (122)	United Kingdom	Belfast; London;Glasgow; Manchester; Cardiff	non-EU/EEA	No	National	Published	16 Apr - 3 Jul	Other	Convenience	Children of employee s	992	6.9% (5.4 - 8.6)	CLIA; CMIA	Abbott Laboratories; Roche Diagnostics; DiaSorin Liaison	IgG	64-94%	98-100%	4	Medium
40											Children of employee s									
41											Children of employee s									
42											Children of employee s									
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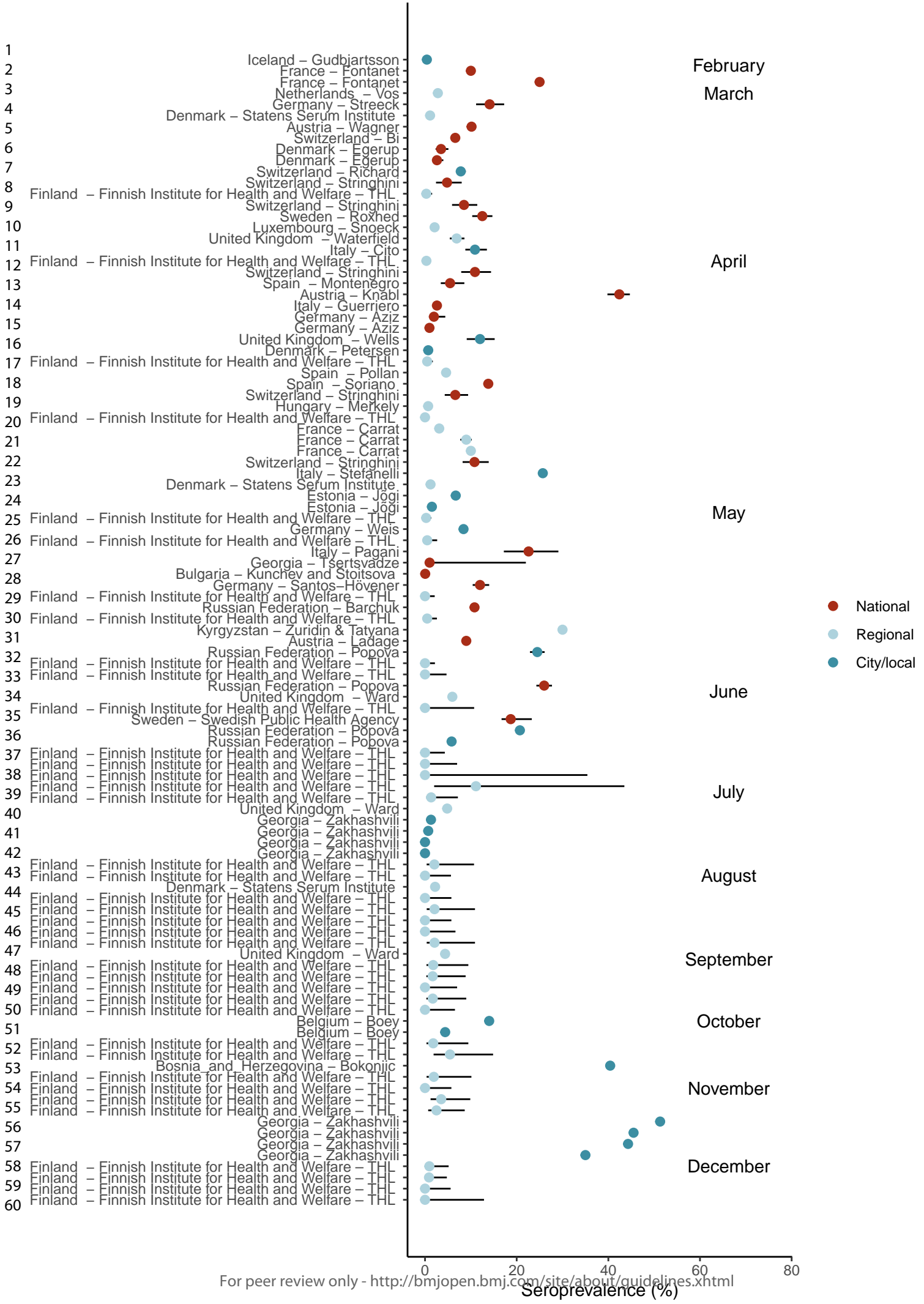
103	Armann (123)	Germany	Eastern Saxony	EU/EEA	No	Regional	Pre-print	25 May - 30 Jun; 15 Sept-13 Oct	Other	Convenience	Teachers and students	1779	0.6%; 0.6%	ELISA; CLIA; CMIA	EUROIMMUN; Diasorin Liaison; Abbott Laboratories	IgG	97.6%	99.3%		
104	Reisinger (124)	Germany	Rostock	EU/EEA	No	City/local	Published	22-29 Apr	Other	Convenience	Children and mothers	401	2.90%	ELISA	EUROIMMUN	IgA; IgG	NR	NR	3	High
105	Tsitsilonis (125)	Greece	Athens	EU/EEA	No	City/local	Published	15 Jun - 15 Jul	Other	Convenience	Employees and students	2500	0.93% (0.27, 2.09) §	CLIA	Roche Diagnostics	Total Abs	100%	99.81%	5	Medium
106	Lastrucci (126)	Italy	Prato	EU/EEA	No	Regional	Published	1 May - 31 May	Multiple	Random	Work-from-home; Support service	1828	1% (0.3-2.0); 1.4% (0.7-2.2)	LFA	Hangzhou Laihe Biotech	IgM; IgG	NR	NR	2	High
107	Soriano (127)	Spain	Madrid	EU/EEA	Yes	City/local	Published	27 Apr - 17 May	Multiple	Convenience	University staff, family members, community	674	13.8%	LFA	PCL Inc	IgM; IgG	NR	NR	3	High
108	Montenegro (128)	Spain	Barcelona	EU/EEA	No	City/local	Published	21-24 Apr; 29 Apr - 6 May	Multiple	Random	HH/C; PSC	311; 634	5.47% (3.44-8.58); 38.49% (34.78%-42.33%)	LFA; LFA; LFA	Livzon; Lysine; Sure Screen	IgM; IgG	Livzon =91.2%; Lysun =98.6%; SureScreen=91%	NR	9	Low
109	Emmenegger (129)	Switzerland	Canton of Zurich	non-EU/EEA	Yes	Regional	Pre-print	Mar - Jul	Multiple	Convenience	BD; PSC;	Total: 33932; Blood donor cohort: 9,102; Patient cohort: 24,830 ;	BDS cohort [§] : April: 1.2%; May: 1.6%; July: 0.7%; Patient cohort [§] : March: 0.3%; April: 1.4%; May - July: 0.9%;	Tripartite Automated Blood Immunoassay (TRABI)	In house	IgG	100%	100%	5	Medium
110	Dopico (130)	Sweden	Stockholm	EU/EEA	No	City/local	Published [^]	4 Mar - 11 Dec	Multiple	Convenience	BD; Pregnant women	2600; 2500	14.8% (12.2-18.0)	ELISA	In house	IgG	Spike 3SD:100% (95% CI [97.5-100.0]); Spike 6SD:100% (95% CI [99.6-100.0]); RBD 3SD:100% (95% CI [98.4-99.4]); RBD 6SD:100% (95% CI [99.6-100.0]); RBD 3SD:99.0% (95% CI [94.2-99.3]);	5	Medium	
111	Davis (131)	United Kingdom	London	non-EU/EEA	No	City/local	Pre-print	Jun	Other	Convenience	University staff	1882	6.6% (5.6-7.8)	LFA	SureScreen	IgM; IgG	89%	100%	4	Medium

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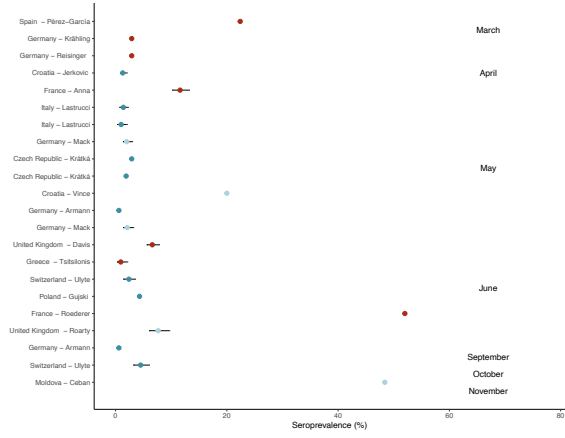
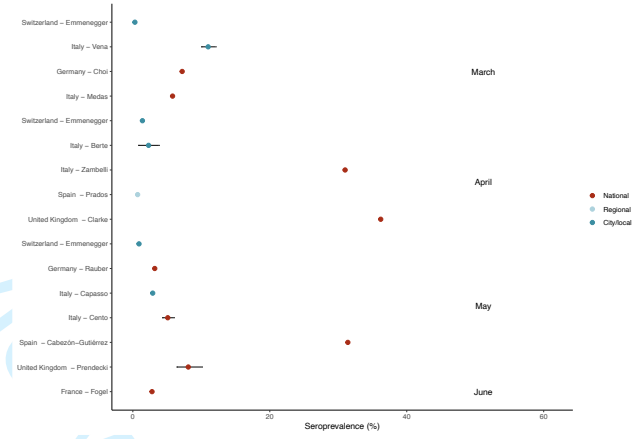
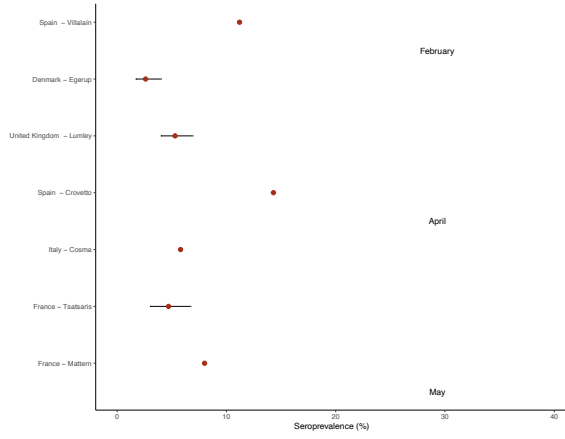
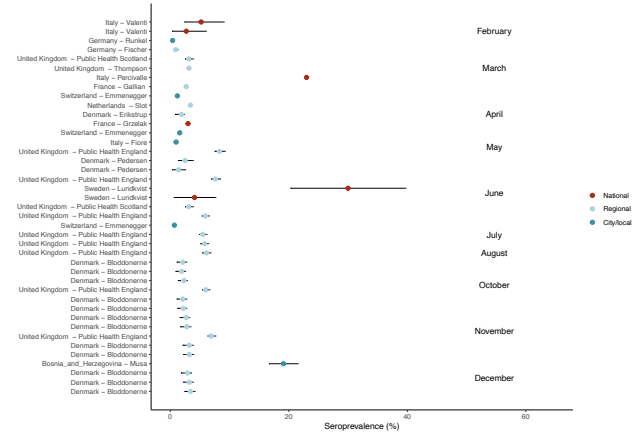
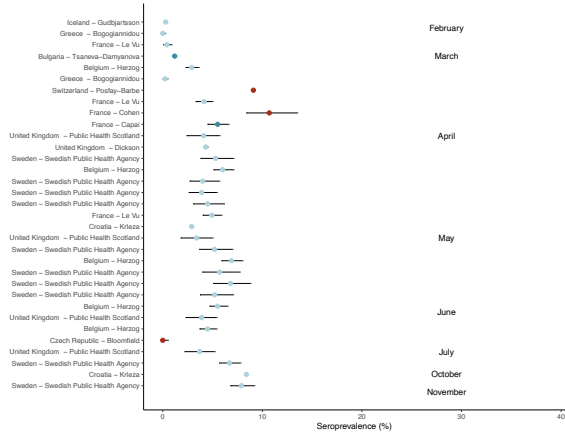
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NR = Not reported; GP = General population; BD= Blood donors; RS = Residual sera; PSC = Patients seeking care (non-COVID-19); Sn: Sensitivity; Sp: Specificity; * LuLISA: Luciferase Linked Immunosorbent Assay; ^ Initially reported to WHO EURO and ECDC in 2020 or in pre-print form and since published;

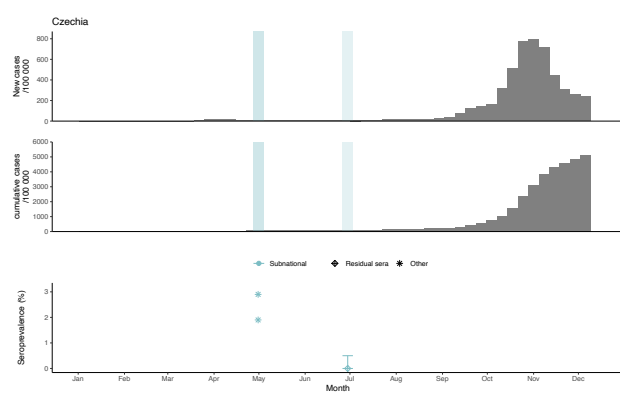
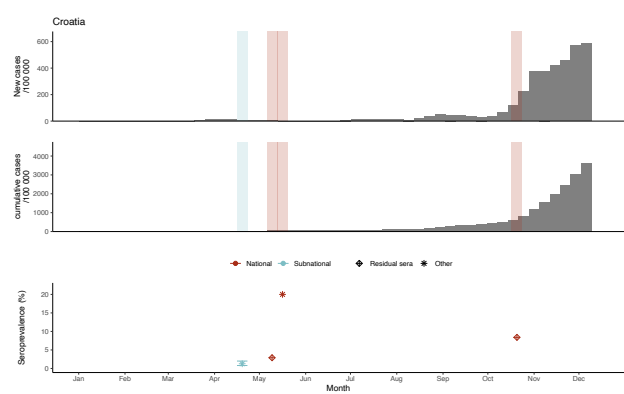
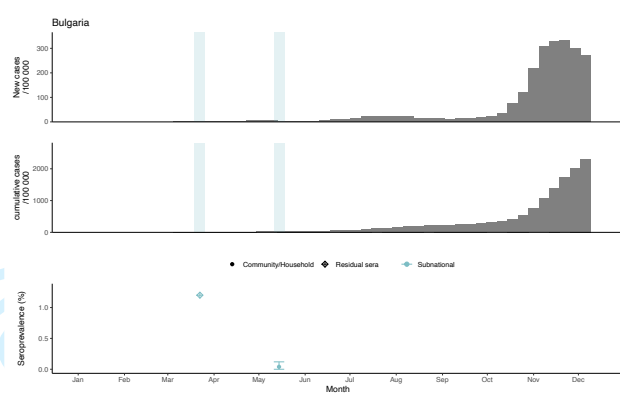
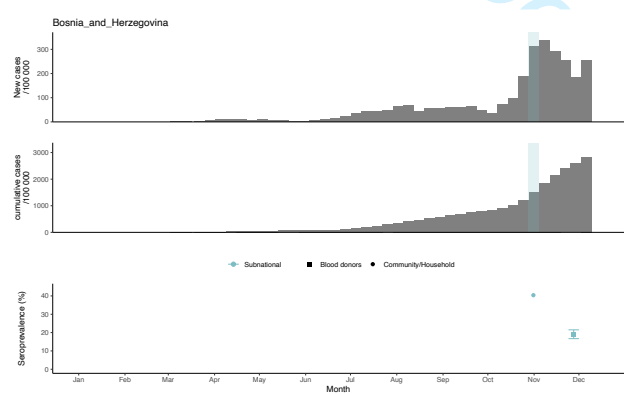
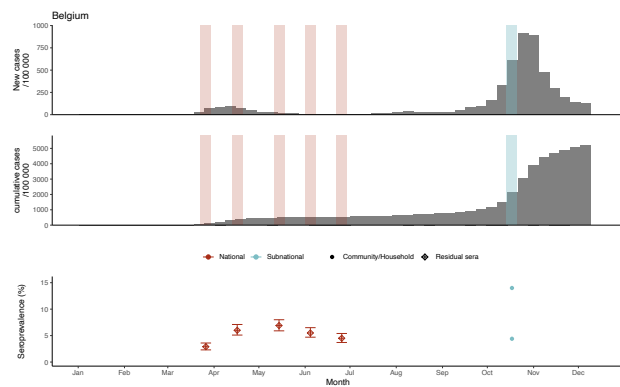
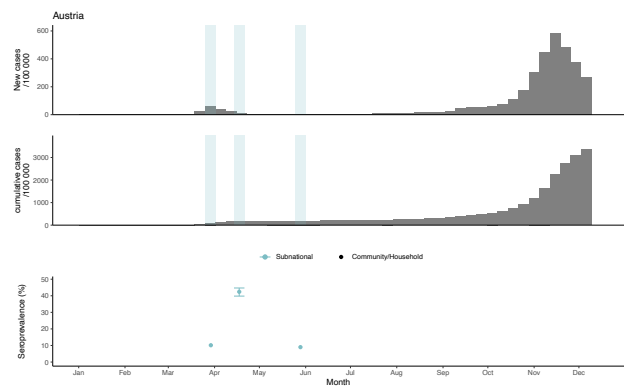
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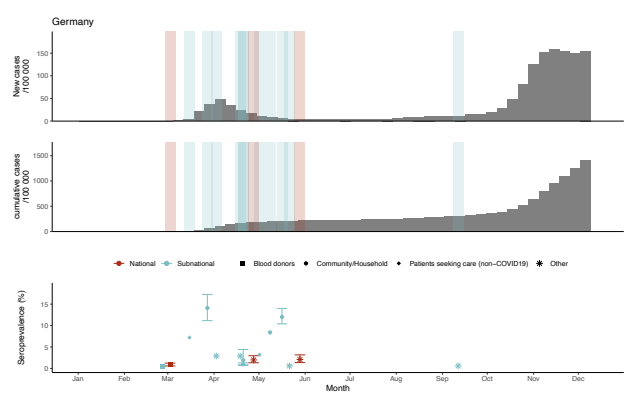
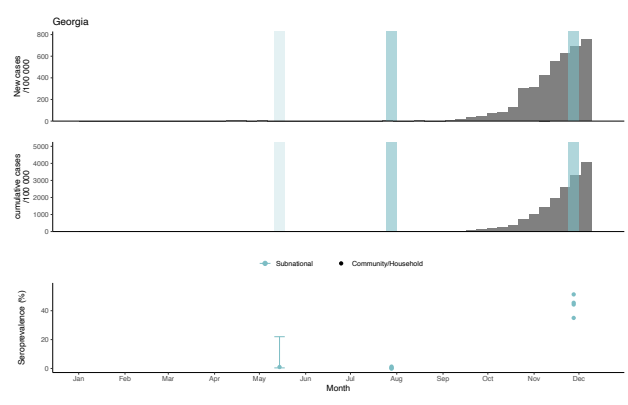
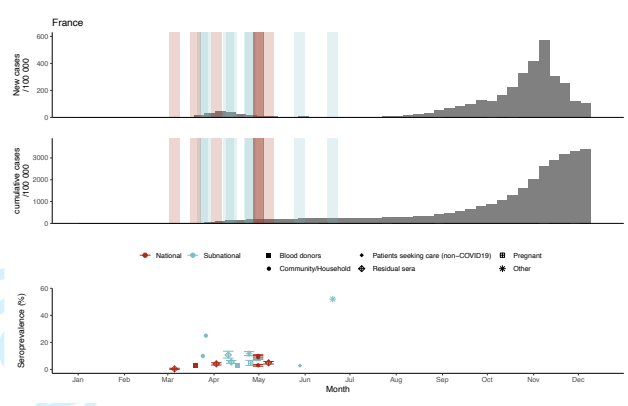
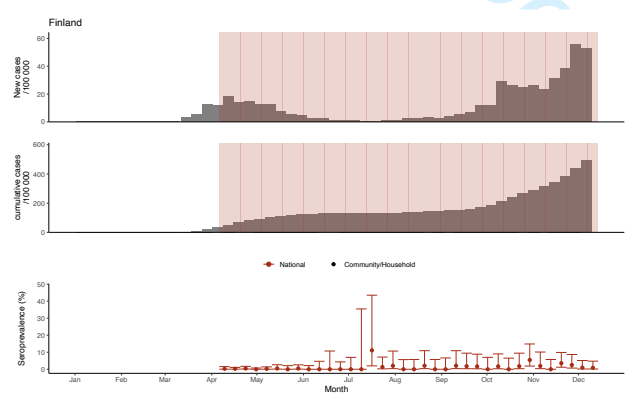
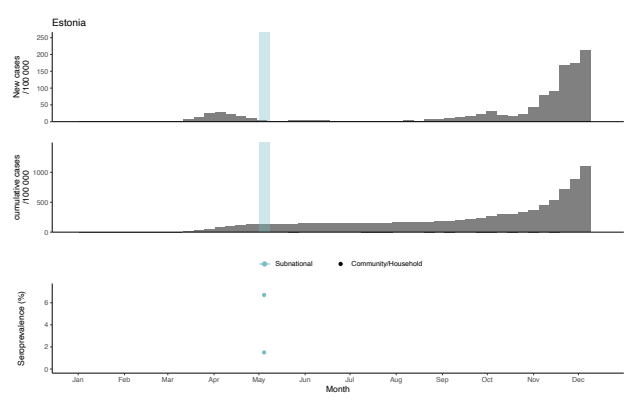
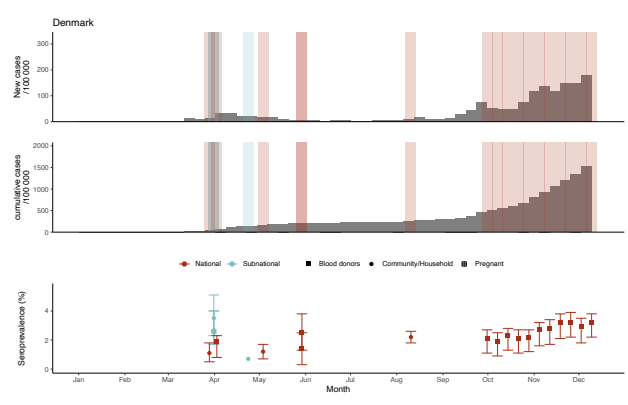
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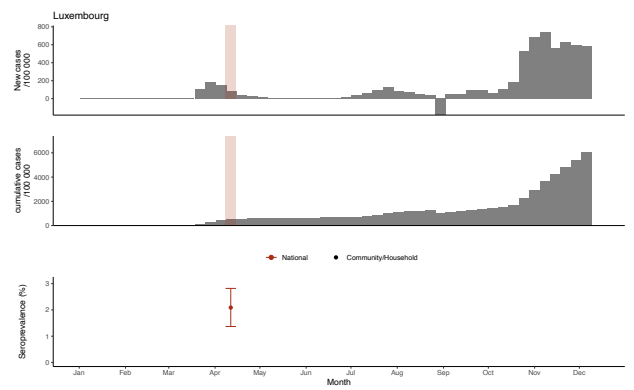
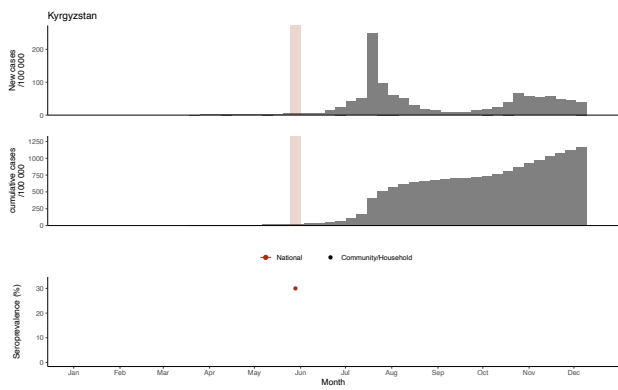
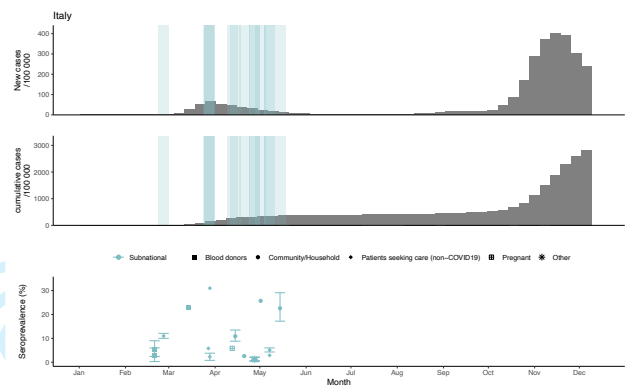
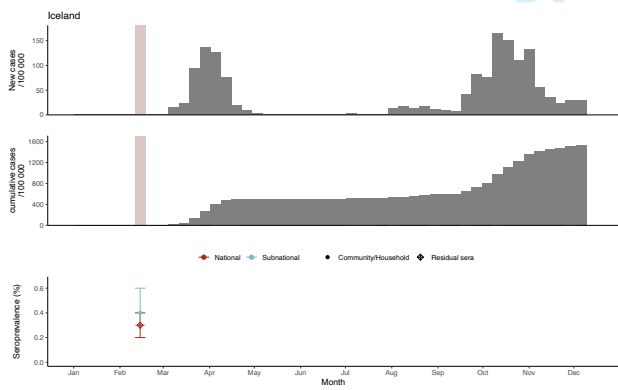
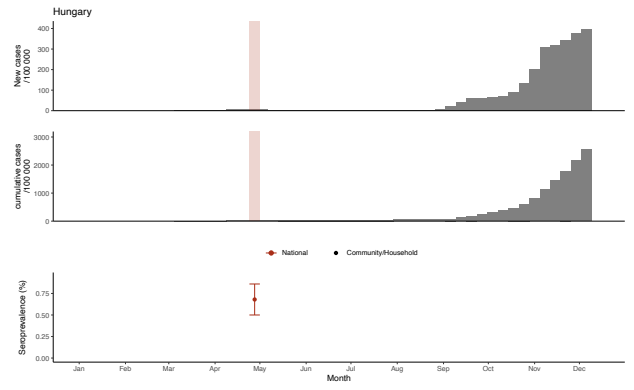
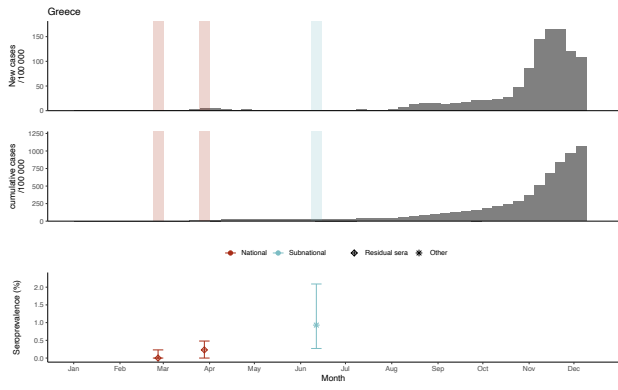
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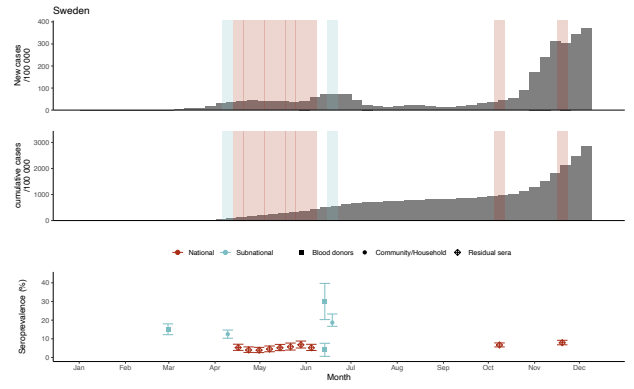
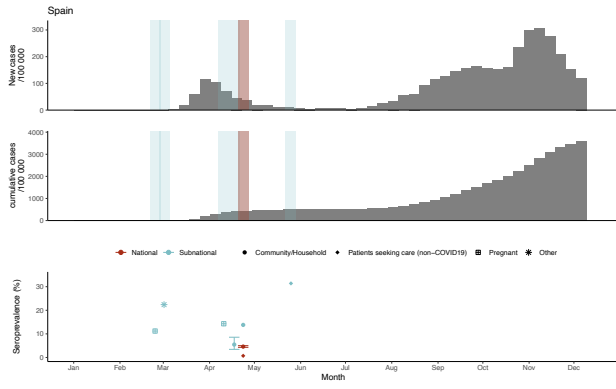
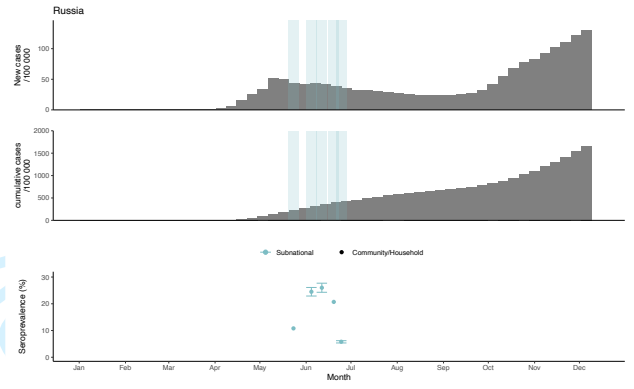
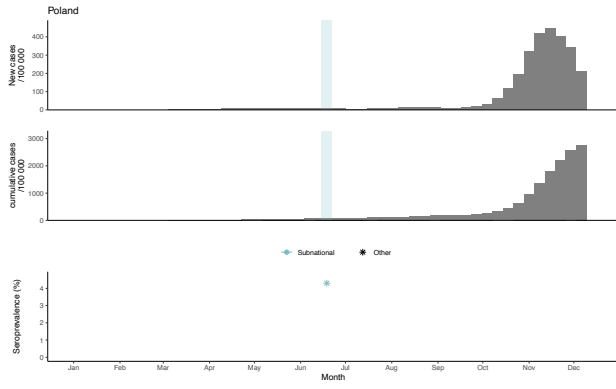
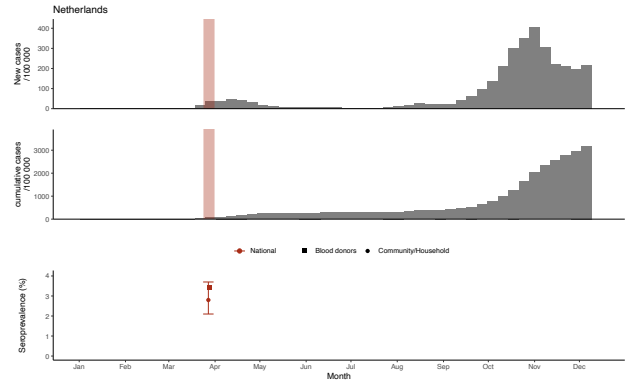
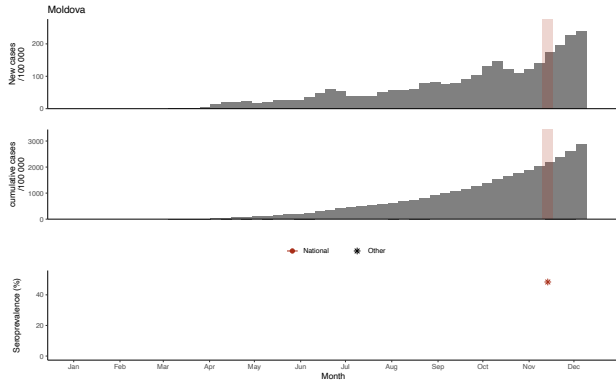
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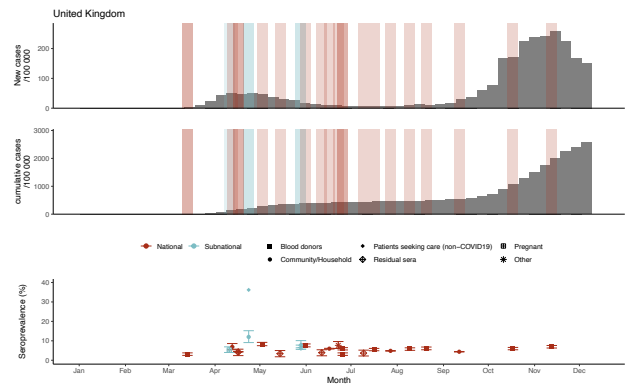
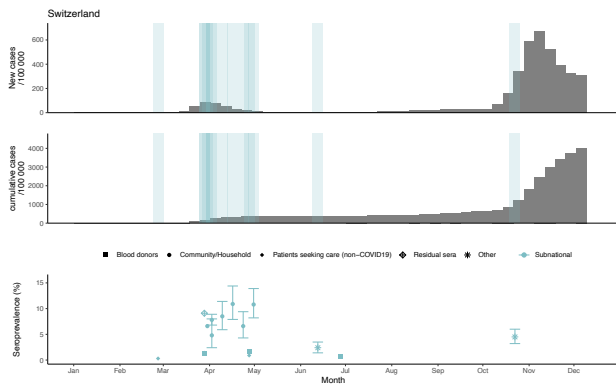


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PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Page 1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Page 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Page 6
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 7
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Page 7, Supplementary Material 2
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Page 7
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Page 7, Supplementary Material 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Page 8
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Page 8 and 9
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Page 8 and 9
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Page 8 and 9
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Page 8 and 9, Supplementary Table 1
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Page 8 and 9
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Page 8
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Page 8
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Page 8 and 9
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Page 8 and 9
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Page 8 and 9



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Section and Topic	Item #	Checklist item	Location where item is reported
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	N/A
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Page 8 and 9, Supplementary Table 1
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Page 9, Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Figure 9
Study characteristics	17	Cite each included study and present its characteristics.	Table 1, Supplementary Table 2, Figure 2
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Page 17, Supplementary Table 1
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Table 1, Supplementary Table 2, Figure 3.
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Page 17, Supplementary Table 1
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Page 9-16, Figure 3
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Page 9-16, Figure 3
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Page 9-16, Figure 3
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Page 17-20
	23b	Discuss any limitations of the evidence included in the review.	Page 20-21
	23c	Discuss any limitations of the review processes used.	Page 20-21
	23d	Discuss implications of the results for practice, policy, and future research.	Page 21
OTHER INFORMATION			



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Section and Topic	Item #	Checklist item	Location where item is reported
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Page 7
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Page 7
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Page 7
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Page 23
Competing interests	26	Declare any competing interests of review authors.	Page 23
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Supplementary Table 2

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71
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