Public Health England

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Serological Surveillance: Summary report 13
15th July 2020

Key findings:

This week's report provides:

- **Analysis of an additional :-**
    - **2093 adult blood donor samples (aged 17-69 years) (collected in early July (weeks 27 and 28)) from the London and North West regions.**
    - **80 paediatric residual samples from Great Ormond Street Hospital (GOSH) for weeks 21 to 23 (19th May to 3rd June).**
    - **3521 results from patients who had a routine blood test via the Royal College of General Practioners Research and Surveillance Centre (RCGP-RSC) network during the period 1 May – 22 June, and also had available data regarding their ethnicity.**
- **Adjusted prevalence amongst blood donors in weeks 27-28 has plateaued in North West (8.3% (6.3% - 10.6%)). This compares with 9% (6.9% - 11.4%) for week 23. Adjusted prevalence in London is lower in weeks 27-28 at 9.9% (7.8% - 12.3%)) compared with 13.3% (10.7% - 16.2%) for weeks 25-26.**
- **Difference in prevalence by age band have narrowed in both adult and paediatric populations, due to lower prevalence within the younger age bands, and relatively higher prevalence among the older age bands.**
- **Analysis of RCGP data displayed a higher prevalence among Asian and black ethnicities than among white ethnicities; 9.9% (5.8% - 15.6%) among Asian ethnicities, 17.8% (8.0% - 32.1%) among black ethnicities and 4.9% (4.2% - 5.8%) among white ethnicities.**

This week's report includes additional data from testing adult samples from blood donors in England (NHS Blood and Transplant (NHSBT) with regions sampled at different time periods. We present results from testing a seventh set of samples from London, and the fourth set of samples from the North West (comprising 2093 new samples in total). We also present the results of testing 80 additional residual samples from individuals under 18 years from Great Ormond Street Hospital (GOSH) for weeks 21 -23 (19th May to 3rd June).

Results

Blood donor data (aged 17-69 years)

Seroprevalence estimates presented here are based on a total of 27575 adult samples from NHSBT and Welsh Blood Service (WBS) and includes the results of 1079 new samples from London and 1014 new samples from the North West (collected between the 1st and 6th of July (weeks 27 and 28)).

Seroprevalence estimates amongst blood donors were adjusted for the sensitivity and specificity of the EuroImmun assay, based on sensitivity of 83.0% (76.6-88.3%) and specificity of 99.3% (98.6-99.7%) and uncertainty using a Bayesian approach. Sensitivity and specificity have been updated this week on the basis of new testing data and are now restricted to convalescent sera taken 3-6weeks after onset. (**Appendix 3**)

National prevalence estimates

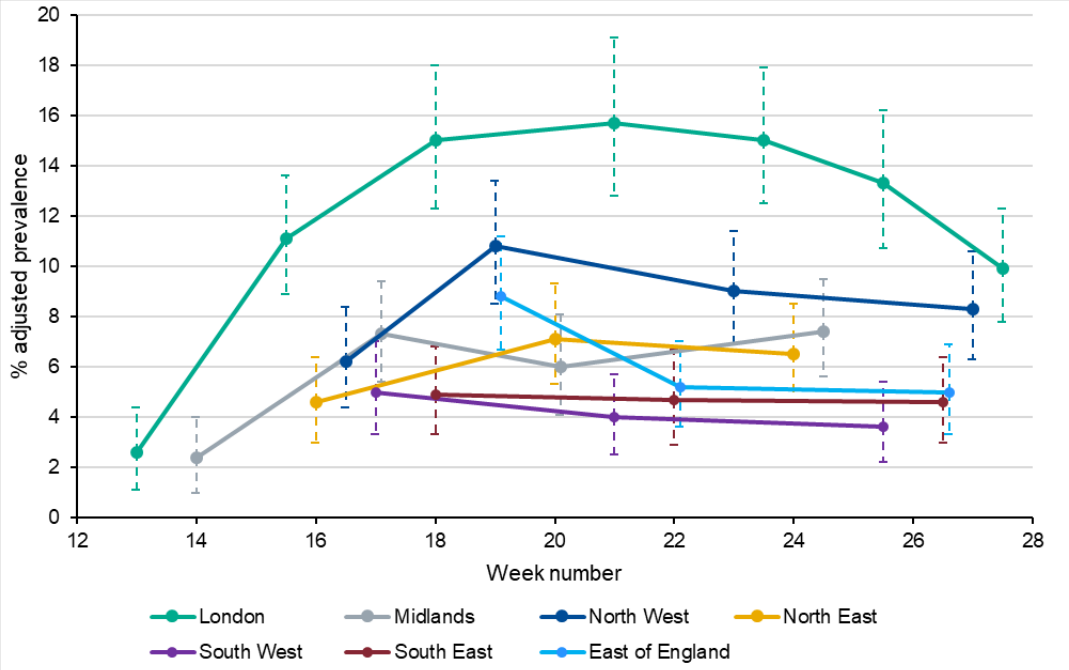
Samples are collected from each region once every four weeks, except London where samples are collected once every two weeks. We therefore produce national prevalence estimates based on a rolling 4-weekly period. 8266 samples were available during the period 8 June- 6 July, of which 576 were positive.

Overall population weighted (by age group, sex, NHS region) prevalence among blood donors was 6.7% (6.1% - 7.3%) (unadjusted) or 7.1% (6.5% - 7.8%) after adjustment for sensitivity and specificity for the period 8th June to 6th July (weeks 24-28). This compares with 7.5% (6.9% - 8.2%) (unadjusted) or 8.2% (7.4% - 9.0%) (adjusted) for the period of 13th May to 7th June (weeks 20-23).

Regional prevalence estimates (unweighted) over time

The additional results from weeks 27 and 28 (**Figure 1**) show that adjusted prevalence in London is lower at 9.9% (95% CrI 7.8% - 12.3%) in week 27 compared with 13.3% (95% CrI 10.7% - 16.2%) in week 25. The week 27 data for the North West (the fourth sample set from this region) indicates a plateau; adjusted prevalence was 9% (95% CrI 6.9% - 11.4%) in week 23, and is 8.3% (95% CrI 6.3% - 10.6%) in week 25. (**Table 1, Appendix 1**).

Figure 1: *Adjusted SARS-CoV-2 antibody seroprevalence in UK blood donors*

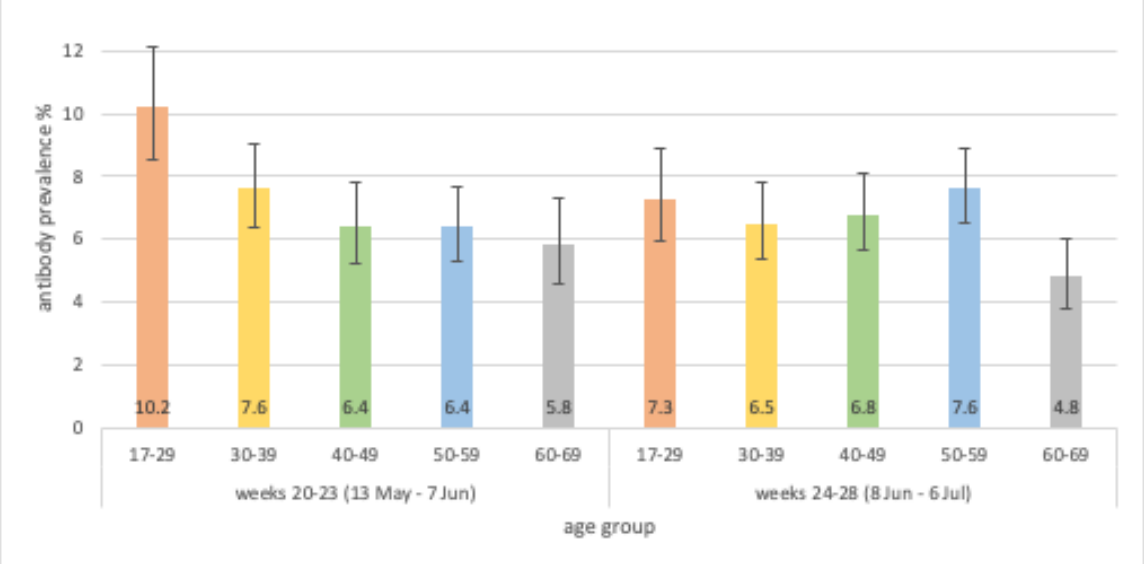


*using Euroimmun assay adjusted for sensitivity (83.2%) and specificity (99.3%)
**error bars show 95% confidence intervals

Please note that about 1-2% of the samples come without demographic data, and hence prevalence estimates in this report are based on the 98-99% sets with available data.

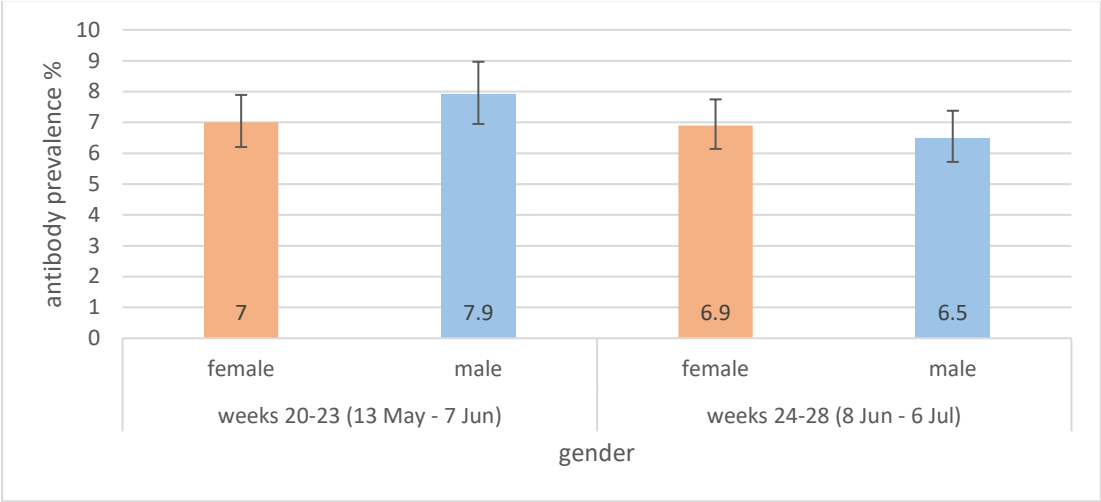
When stratified by age, the population weighted NHSBT prevalence estimates display a similar pattern to previous analyses **(Figure 2)**. Young adults displayed a significantly higher prevalence than older age bands in weeks 20-23, but the difference between age groups evened out in weeks 24-28; largely due to lower prevalence among people aged 17 – 39, and higher prevalence among people aged 40 – 59.

Figure 2: Population weighted EuroImmun % positive (with 95% CI) by age group in blood donors, weeks 20-23 and weeks 24-28



Analysis of results by gender did not display any clear patterns in this population with prevalence estimate similar in males and females for the period 8th June to 6th July. (**Figure 3**).

Figure 3: Population weighted EuroImmun % positive (with 95% CI) by gender in blood donors, weeks 20-23 and weeks 24-28



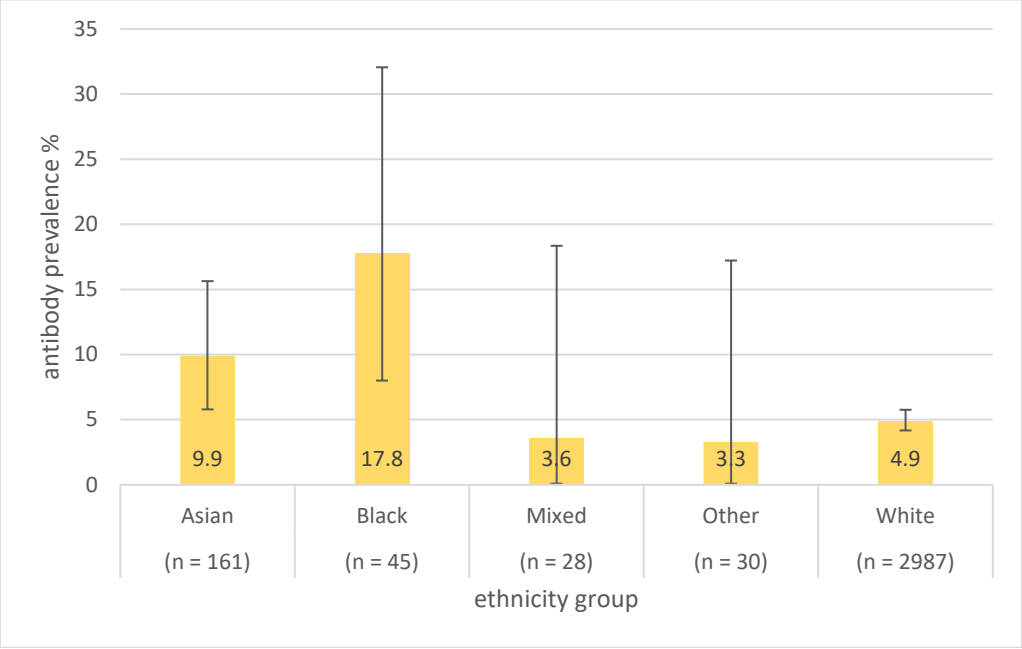
RCGP Ethnicity analysis

Ethnicity information was available for 3521 patients whose sample was collected at their GP during a consultation for a routine blood test via the Royal College of General Practioners Research and Surveillance Centre (RCGP-RSC) network of participating practices. These data are based on samples collected during the period 1 May – 22 June. Patients covered a wide age range from age 9 to age 110. Samples were tested using the Abbott assay, with 95.7% sensitivity (95% CI 91.4 – 98.3%) and 99.1% specificity (95% CI 98.4 – 99.6%); estimates are not adjusted.

Observed antibody prevalence (positive/total) was 9.9% (5.8% - 15.6%) among Asian ethnicities, 17.8% (8.0% - 32.1%) among black ethnicities and 4.9% (4.2% - 5.8%) among white ethnicities, suggesting higher prevalence among Asian and black ethnicities than among white ethnicities (**Figure 2**). The number of samples was very low for the mixed and other ethnicities groups, so little can be said about prevalence among these ethnic groups.

The concentration of the Asian and black population was higher in London and in adolescents and young adults (data not shown). To check whether the difference in prevalence by ethnicity could be explained by regional or age differences, a logistic regression model was fitted including ethnicity, NHS region and broad age group (9-29, 30-64, 65+) as explanatory variables; odds ratios (OR) are given in **Appendix 2, Table 2**. After adjustment for age group and region, the odds of a positive test result was higher among both Asian and Black ethnicities compared with white ethnicities, however this result was only statistically significant among Black ethnicities (Asian OR 1.5 [95% CI 0.8 - 2.8], Black OR 2.8 [95% CI 1.2 – 6.9]).

Figure 2. Antibody prevalence by ethnicity using the Abbott assay during the period 1 May – 22 June.



Seroprevalence estimates in paediatric samples

The results of 80 residual sera from Great Ormond Street Hospital (GOSH) for weeks 18-23, are presented (**Table 2**).

***Table 2**: Summary of GOSH (unweighted) Prevalence Estimates (ages 1 – 18) by period of sampling, using the Euroimmun assay*

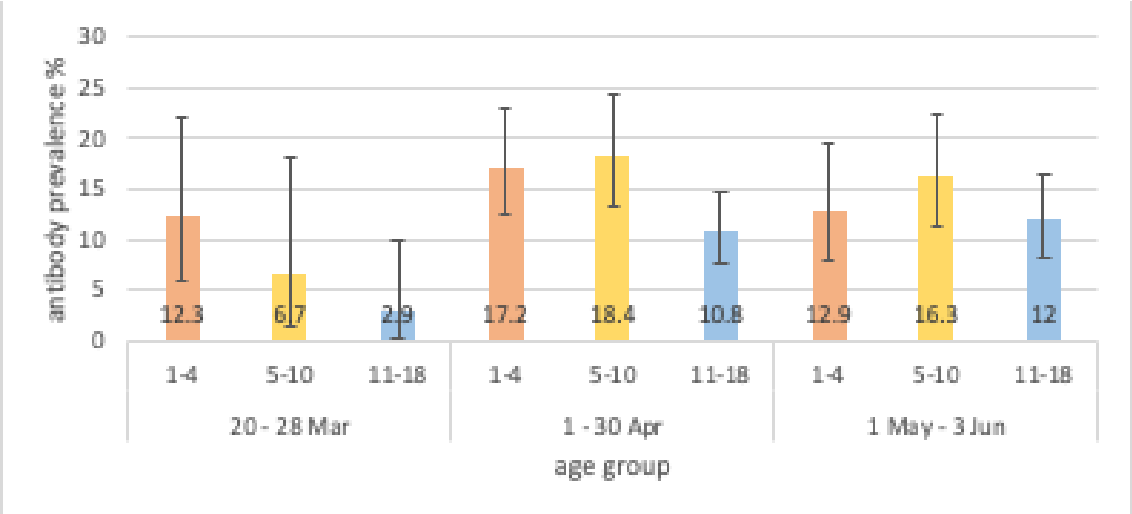
date range	pos	ind	Neg	total	% pos (95% CI)	adjusted prevalence (95% CrI)
20-28 Mar	14	7	169	190	7.4% (4.1% - 12.1%)	8.1% (4.2% - 13.5%)
1-30 Apr	105	18	601	724	14.5% (12.0% - 17.3%)	16.8% (13.6% - 20.4%)
1 May – 3 June	80	12	502	594	13.5% (10.8% - 16.5%)	15.5% (12.2% - 19.3%)

The addition of these 80 additional samples has not changed the observed pattern of prevalence among these paediatric patients – there is an increase in prevalence between February and early April, followed by a plateau in prevalence between April and late May.

When stratified by age, the GOSH prevalence estimates display a similar pattern to the results from testing blood donor samples **(Figure 3)**. The youngest age band displayed a significantly higher prevalence than older age bands in mid March, however the difference in prevalence evened out between early May and early June, largely due to increased prevalence among children aged 5 – 18. Most recently, primary school aged children (5-10) have displayed the highest prevalence.

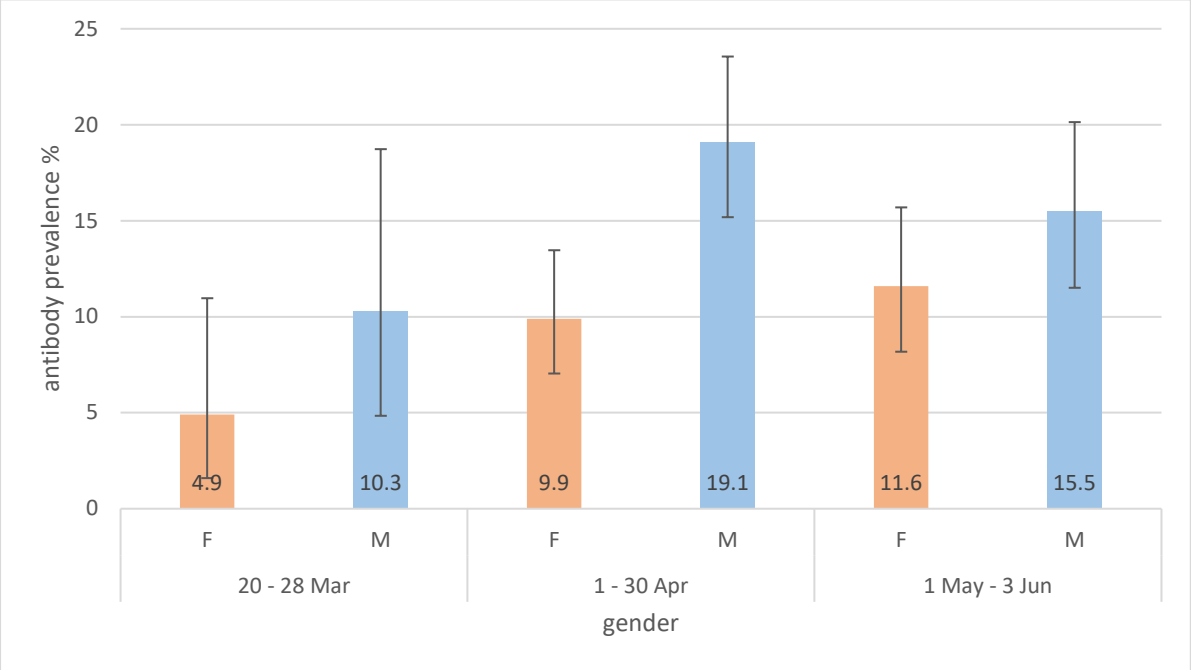
Prevalence estimates for GOSH are consistently higher than What's the Story and SEU/paediatric collections – this is likely explained by a combination of factors including i) location of sampling with patients attending GOSH living predominantly in London and the neighbouring regions where prevalence is higher than in the rest of the population and ii) the fact that as a tertiary paediatric centre, patients attending GOSH are unlikely to be representative of the wider paediatric population.

***Figure 3**: EuroImmun % positive by age group in GOSH patients, weeks 18-20 (27 April - 11 May)*



Analysis of GOSH results by age continues to show an increased prevalence among male children (**Figure 4**).

Figure 4: EuroImmun % positive by gender and month in GOSH patients



Comments

We report national prevalence estimates of 7.1% (6.5% - 7.8%) based on testing adult blood donors for the period 8th June to 6th July (weeks 24-28).

Updated regional NHSBT prevalence estimates based on the results of testing the seventh set of samples from London, and the fourth set of samples from the North West (weeks 27 - 28) are presented. The latest results in the North West are consistent with prevalence reaching a plateau. A lower prevalence, however, has been seen in London. Any changes in prevalence estimates over time also need to take account of potential changes in the precise locations of sampling in each region over time, assay variability and waning antibodies. Prevalence accross London is more homogeneous than other regions, but appears to be slightly higher in inner London. Location of sampling alone cannot explain the drop in London prevalence this week as the representation of samples from inner London was similar to past weeks. From the beginning of June individuals have been advised not to donate blood for 28 days following resolution of symptoms suggestive of COVID-19, an increase from previous exclusion of 14 days. Differences between age bands with regards to prevalence appear to have narrowed within this population, with increasing prevalence being observed in older populations and decreased prevalence in young adults. Changes in the donor population with the easing of lockdown measures may also play a role in the trends observed. Waning immunity is likely to only be contributing a very small part to the recent lower estimates. We continue to observe relatively low numbers of samples with results in the equivocal range. Furthermore, based on the results of testing convalescent sera and samples from the ESCAPE study (longituindal study with monthly collection of blood samples from PHE /NHS employees which has been presented in previous reports) there appears to be limited evidence of seroreversion from samples tested using the Euroimmun assay.

Data from routine collections from within the Royal College of General Practioners Research and Surveillance Centre (RCGP-RSC) network is also presented. These data show a higher prevalence among Asian and black ethnicities than among white ethnicities, a result that is similar to other analyses.

Updated prevalence estimates for the GOSH data are also presented. Prevalence in this population appears to be reaching a plateau, consistent with the trends observed in adults. When stratified by age, the previously observed gap in prevalence has narrowed over time, with prevalence in school aged children increasing over time. GOSH prevalence estimates are higher than the estimates in other paediatric collections – likely due to population characteristics. In general, the currently available data from a range of paediatric collections show a lower prevalence in children than in adults.

Appendix 1: NHSBT data

***Table 1**: Summary of NHSBT Prevalence Estimates by region and period of sampling, using the Euroimmun assay*

Region	date range	week	pos	ind	neg	total	% pos (95% CI)	adjusted prevalence (95% CrI)
NHS blood & transplant								
London	26-27 Mar	13	22	11	724	757	2.9% (1.8% - 4.4%)	2.6% (1.1% - 4.4%)
	9-13 Apr	15-16	107	15	963	1085	9.9% (8.2% - 11.8%)	11.1% (8.9% - 13.6%)
	1-3 May	18	127	10	837	974	13.0% (11.0% - 15.3%)	15% (12.3% - 18%)
	21-22 May	21	109	21	667	797	13.7% (11.4% - 16.3%)	15.7% (12.8% - 19.1%)
	5-8 Jun	23-24	143	9	942	1094	13.1% (11.1% - 15.2%)	15% (12.5% - 17.9%)
	19-22 Jun	25-26	106	12	793	911	11.6% (9.6% - 13.9%)	13.3% (10.7% - 16.2%)
	3-6 Jul	27-28	96	11	972	1079	8.9% (7.3% - 10.8%)	9.9% (7.8% - 12.3%)
Midlands	2-3 Apr	14	25	13	878	916	2.7% (1.8% - 4.0%)	2.4% (1% - 4%)
	23-24 Apr	17	70	9	964	1043	6.7% (5.3% - 8.4%)	7.3% (5.4% - 9.4%)
	14-15 May	20	49	6	815	870	5.6% (4.2% - 7.4%)	6% (4.1% - 8.1%)
	11 Jun	24-25	77	7	1040	1124	6.9% (5.4% - 8.5%)	7.4% (5.6% - 9.5%)
NE	14-16 Apr	16	46	12	959	1017	4.5% (3.3% - 6.0%)	4.6% (3% - 6.4%)
	13-14 May	20	67	8	939	1014	6.6% (5.2% - 8.3%)	7.1% (5.3% - 9.3%)
	10-12 Jun	24	64	5	987	1056	6.1% (4.7% - 7.7%)	6.5% (4.7% - 8.5%)
NW	15-20 Apr	16-17	55	11	870	936	5.9% (4.5% - 7.6%)	6.2% (4.4% - 8.4%)
	6-8 May	19	92	16	852	960	9.6% (7.8% - 11.6%)	10.8% (8.5% - 13.4%)
	4-6 Jun	23	83	6	931	1020	8.1% (6.5% - 10.0%)	9% (6.9% - 11.4%)
	1-3 July	27	77	15	922	1014	7.6% (6.0% - 9.4%)	8.3% (6.3% - 10.6%)
SW	24-26 Apr	17	42	8	815	865	4.9% (3.5% - 6.5%)	4.8% (2.8% - 6.9%)
	21-22 May	21	42	14	994	1050	4.0% (2.9% - 5.4%)	3.7% (1.9% - 5.6%)
	19 – 22 Jun	25-26	38	4	970	1012	3.8% (2.7% - 5.1%)	3.4% (1.6% - 5.2%)
SE	30 Apr - 1 May	18	49	11	960	1020	4.8% (3.6% - 6.3%)	4.9% (3.3% - 6.8%)
	28-29 May	22	38	7	787	832	4.6% (3.3% - 6.2%)	4.7% (2.9% - 6.7%)
	26-29 Jun	26-27	46	7	961	1014	4.5% (3.3% - 6.0%)	4.6% (3% - 6.4%)
EE	7-10 May	19	81	13	921	1015	8.0% (6.4% - 9.8%)	8.8% (6.7% - 11.2%)
	28-29 May	22	55	6	1039	1100	5.0% (3.8% - 6.5%)	5.2% (3.6% - 7%)
	26-29 Jun	26-27	48	3	943	994	4.8% (3.6% - 6.4%)	5% (3.3% - 6.9%)
Welsh blood service								
Wales		17	34	4	968	1006	3.4% (2.4% - 4.7%)	3.2% (1.8% - 4.8%)

Appendix 2: RCGP Ethnicity analysis

Table 2. Odds ratio estimates given by a logistic regression of positive Abbott test result on region, age group and ethnicity. RCGP-RSC data, 1 May – 22 June.

	odds ratio (95% CI)
NHS region	
London	1 (ref)
East of England	1 (0.4 - 2.8)
Midlands	0.7 (0.3 - 1.5)
North East and Yorkshire	0.6 (0.3 - 1.3)
North West	0.6 (0.3 - 1.3)
South East	0.5 (0.2 - 1)
South West	0.5 (0.3 - 1.1)
age group	
9-29	2 (1.3 - 3.2)
30-64	1 (ref)
65+	0.7 (0.4 - 1)
ethnicity	
Asian	1.5 (0.8 - 2.8)
Black	2.8 (1.2 - 6.9)
Mixed	0.5 (0.1 - 3.7)
Other	0.6 (0.1 - 4.2)
White	1 (ref)

Appendix 3: Sensitivity & Specificity

Data on testing of convalescent and baseline sera will be updated periodically, and has been updated this week (Table 3). Sensitivity is based solely on convalescent sera in the period 3 to 6 weeks post infection, this is when antibody responses appear to peak. It has been noted that antibody waning appears to affect Abbott positivity rates in the period 7 to 13 weeks post infection, while EuroImmun and RBD appear unaffected over this period (Table 4). For Abbott adjustments going forward we will be using a cut off of 0.8 for adjustments (i.e. positive + equivocal, rather than the positive cut-off at 1.4) to better help pick these up. However, use of data from the 3-6 post-infection period for sensitivity adjustment means that any adjustment will be minimal.

Table 3. Data used in sensitivity and specificity adjustments.

	Assay	Positive	Equivocal	Negative	Total	adjustment cut-off	
convalescent sera 3-6 weeks post infection							sensitivity
	EuroImmun	142	10	19	171	pos (1.1)	83% (76.6-88.3)
	Abbott	150	6	7	163	equiv (0.8)	95.7% (91.4-98.3)
	RBD	160	4	8	172	pos (5)	93% (88.1-96.3)
baseline sera							specificity
	EuroImmun	160	4	8	172	pos (1.1)	99.3% (98.6-99.7)
	Abbott	2	8	1135	1145	equiv (0.8)	99.1% (98.4-99.6)
	RBD	162	12	1143	1317	pos (5)	98% (97-98.8)

Table 4. Sensitivity by time since onset

Assay	Interval since onset	Positive	Equivocal	Negative	Total	Sensitvity	note
Euroimmun							equivocal treated as negative
	<3w	3		2	5	60.0%	
	3to6w	142	10	19	171	83.0%	
	7to10w	10		2	12	83.3%	
	11to13w	53	5	4	62	85.5%	
Abbott							equivocal treated as positive
	<3w	5			5	100.0%	
	3to6w	150	6	7	163	95.7%	
	7to10w	9	2	1	12	91.7%	
	11to13w	48	7	7	62	88.7%	
RBD							equivocal treated as negative
	<3w	3		2	5	60.0%	
	3to6w	160	4	8	172	93.0%	
	7to10w	10		2	12	83.3%	
	11to13w	57	4	1	62	91.9%	

Appendix 4: Statistical methods

The unweighted observed prevalence, $prev_{obs}$, is calculated as n^+/N, where n^+ is the number of individuals who tested positive and N is the total number of individuals tested with an available result. 95% exact confidence intervals were calculated for $prev_{obs}$ in STATA (version 14).
Population weighted observed prevalences for NHSBT data were calculated using svy commands with the poststrata() option in STATA (version 14). See the STATA Survey Data Refence Manual for methodological details.

It is understood that all assays are imperfect and can sometimes give false positive and false negative results, with probability (1-*Sp*) and (1-*Se*) respectively, where *Sp* denotes the Specificity or the probability that the test gives a negative result in individuals who have not experienced the disease, and *Se* denotes the Sensitivity or the probability that the test gives a positive result in individuals who have experienced the disease. The adjusted prevalence, denoted $prev_{adj}$, should better reflect the proportion of the population that have experienced the disease; this is related to the observed prevalence as follows:

$$prev_{obs} = Se \times prev_{adj} + (1 - Sp) \times \left(1 - prev_{adj}\right)$$

(see Diggle 2011, Lewis & Torgerson 2012). This relation was incorporated in a Bayesian model, along with the sampling distribution for positive tests n^+~Binomial(N, $prev_{obs}$). The sensitivity and specificity are not known exactly, but are informed by data. Counts of true positives and false negatives in convalescent sera were used to estimate the sensitivity, and similarly counts of true negatives and false positives in pre-covid19 baseline sera were used to estimate the specificity. The sensitivity, *Se*, and specificity, *Sp*, were included in our Bayesian model each by way of a conjugate Beta-Binomial model with a Beta(0.5,0.5) reference prior, thus uncertainty in their true value was taken into account.

In unweighted adjustment models, we use a Beta(0.5,0.5) (Jeffreys) prior for the adjusted prevalence $prev_{adj}$. MCMC models were run using the NIMBLE package in R, default sampler, 500,000 iterations with a burn-in of 1,000 iterations and a thinning interval of 5.
Models to estimate population weighted $prev_{adj}$, were further extended to a multilevel logistic regression model, including a random effect for age and region specific seroprevalences (plus a fixed effect for gender when modelling the NHSBT data), following Park et al (2004)'s multilevel regression and poststratification (MRP) models. If each `cell' combination of age and region (and gender, if included) is denoted *j*, then the weighted or poststratified prevalence is given by

$$prev_{weighted} = \frac{\sum_j N_j prev\_adj_j}{\sum_j N_j}$$

Where N_j denotes the population of each cell taken from ONS data. MCMC models were run using STAN and the rstan package in R, 4 chains of length 25,000, with a burn-in of 1,000 iterations.

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