Serological Surveillance: Summary report 18

Key findings:
This fortnightly report provides an analysis of:

- an additional 4074 adult blood donor samples (aged 17-84 years) collected in early September- : weeks 35-36 from the Midlands and North East and Yorkshire and week 37 from the London and the South West regions.
- 8929 samples from from patients aged 17-64 years, attending their GP for a routine blood test, during the period 16th March – 14th August.
- 2523 samples from patients aged 17-64 years from the SEU residual collection, collected during the period 1st Februray – 8th September.

- Overall population weighted (by age, sex, NHS region) among blood donors was 5.6% (95% CrI 5.1% - 6.2%) (unadjusted) or 6.1% (95% CrI 5.4% - 6.8 for the period 19th August – 13th September. This represents a continuing plateauing from the previous 4 weekly period where an adjusted prevalence of 6.4% (95%CrI 5.7%-7.1%) was observed between 20th July and 16th August.
- In the South West, adjusted prevalence at week 37 was 3.5% (95% CrI 2.1%-5.2%), slightly higher than the previous estimate of 2.9% (95% CrI 1.5%-4.4%) at week 31. In the Midlands, there was also a slightly higher adjusted prevalence in week 35-36 at 6.8% (95% CrI 4.9%-8.9%) compared to 4.6% (95% CrI 3%-6.5%) in week 31-32. However, this is likely due to geographical variation of the population sampled, with a lower proportion of samples from Birmingham in week 31-32 compared to other sampling periods and suggests a continuing plateauing in these regions.
- Adjusted prevalence in the North East and Yorkshire region was 3.7% (95% CrI 2.4% - 5.7%) in the latest data (week 36) compared to 5.0% (95% CrI 3.3% - 6.9%) observed in the previous survey in week 32.
- Adjusted prevalence in London was 10.8% (95% CrI 8.6%-13.4%) in week 37 compared to 12.6% (95% CrI 10.2%-15.3%) in week 35 and 8.2% (95% CrI 6.2%-10.5%) in week 33. This suggests the recent increases in prevalence observed at week 35 reflects a combination of changes in donor population and some recent increase in prevalence in line with other surveillance data.
- Analysis of samples from working age adults olds attending their GP for routine blood tests (RCGP) and from the residual SEU collection showed evidence of slightly higher prevalence based on testing samples collected in late July/August in comparison to June/early July.
- Prevalence estimates in the RCGP and SEU collections from weeks 25-33 was similar to the blood donors during weeks 25-33, although there was evidence of a higher prevalence in the 60-65 year old age group in the RCGP collections.
- Analysis of RCGP samples from individuals aged 13-97 showed a five-fold higher seroprevalence amongst black ethnicities compared to white ethnicities and 2-3 fold higher seroprevalence in non-smokers compared to active smokers.

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 6th set of samples from the South West and North East and Yorkshire, the 7th set of samples from the Midlands and the 12th set of samples from London (comprising 4074 new samples in total). We also present the results from testing 2523 residual samples from individuals aged 20-64 years collected through the PHE Sero Epidemiology Unit (SEU) and 8929 samples from the same age group collected from patients attending for routine blood tests at RCGP RSC participating practices across England since February 2020.

Results

Blood donor data (aged 17-84 years)

Seroprevalence estimates presented here are based on a total of 47,886 adult samples from NHSBT and Welsh Blood Service (WBS) and includes the results of 1016 new samples from the Midlands and 1032 samples from the North East and Yorkshire collected between 2nd & 6th September (weeks 35-36), and 1016 samples from London and 1010 from the South West collected between 9th & 11th September (weeks 37).

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 (**Appendix 6 & 7)**.

National prevalence estimates

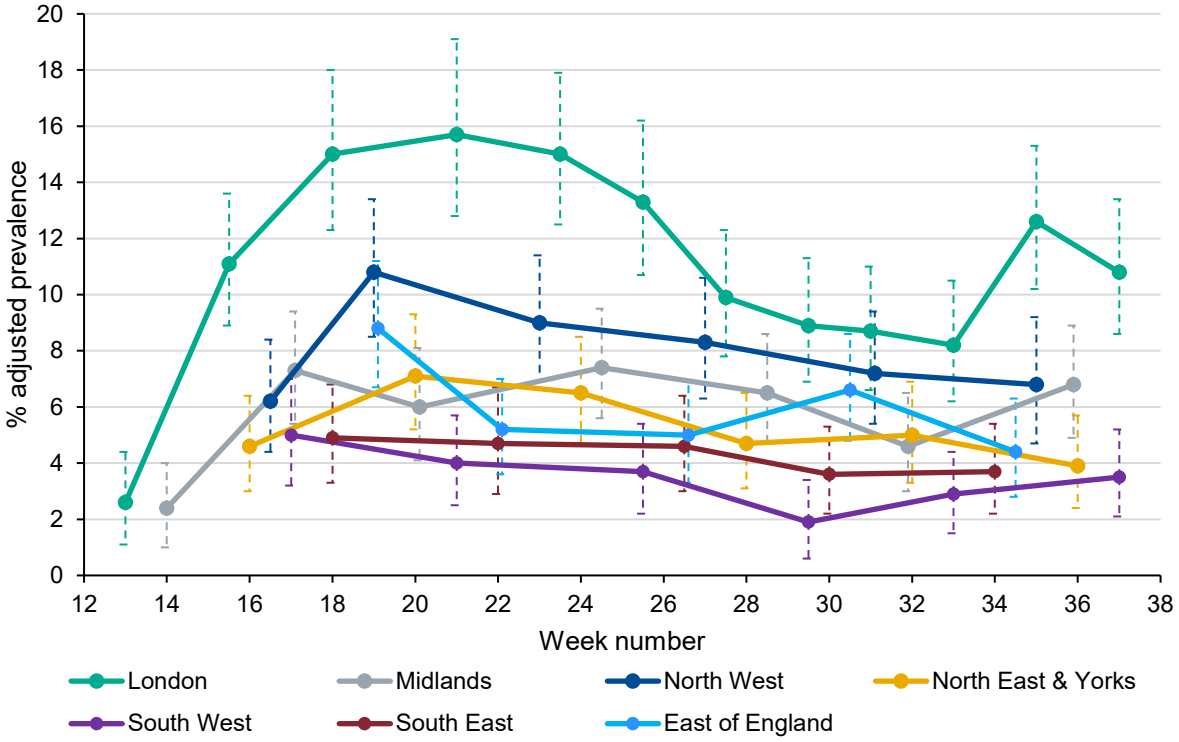
Samples are collected from each region once every four weeks, except London where samples are collected once every two weeks. We therefore produce national prevalence estimates based on a rolling 4-weekly period. 7888 samples were available during the period 19th August- 13th September, of which 484 were positive. Overall population weighted (by age, sex, NHS region) among blood donors was 5.6% (95% CrI 5.1% - 6.2%) (unadjusted) or 6.1% (95% CrI 5.4% - 6.8 %) after adjustment for sensitivity and specificity of the assay **(Table 1)**. This represents a continuing plateauing from the previous 4 weekly period. From week 26 (late June), an exclusion of donors aged 70 years and older donating throughout lockdown was lifted, and therefore data from the most recent sampling periods include donors in this older age group.

Table 1: *Population weighted NHSBT all England prevalence estimates*

date range	weeks	pos	ind	neg	total	population weighted % pos (95% CI)	population weighted modelled adjusted prevalence (95% CrI)
20 Jul - 16 Aug	30-33	510	104	8326	8940	5.3% (4.8% - 5.8%)	6.4% (5.7% - 7.1%)
19 Aug - 13 Sep	34-37	484	102	7302	7888	5.6% (5.1% - 6.2%)	6.1% (5.4% - 6.8%)

Regional prevalence estimates (unweighted) over time

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



*using Euroimmun assay adjusted for sensitivity (83.0%) and specificity (99.3%)

**error bars show 95% credible 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.

In the South West, adjusted prevalence at week 37 was 3.5% (95% CrI 2.1%-5.2%), a slight increase compared to the previous estimate of 2.9% (95% CrI 1.5%-4.4%) at week 33, but 95% credible intervals were overlapping, and therefore was consistent with a plateauing over the latest four week period **(Figure 1, Appendix 1: Table S1)**.

Recent data from the Midlands show a higher adjusted prevalence at 6.8% (95% CrI 4.9%-8.9%) in week 35-36. This compares to 4.6% (95% CrI 3%-6.5%) in week 31-32 **(Figure 1, Table S1)**. This observed increase is likely due to geographical variation of the population sampled, with a lower proportion of samples from Birmingham in week 31-32 compared to other sampling periods (**Appendix 3).** In the North East and Yorkshire NHS region the adjusted prevalence was 3.9% (95% CrI 2.4%-5.7%) in week 36 compared with 5% (95% CrI 3.3%-6.9%) in week 32, similar to the plateauing seen across other regions **(Figure 1, Table S1)**.

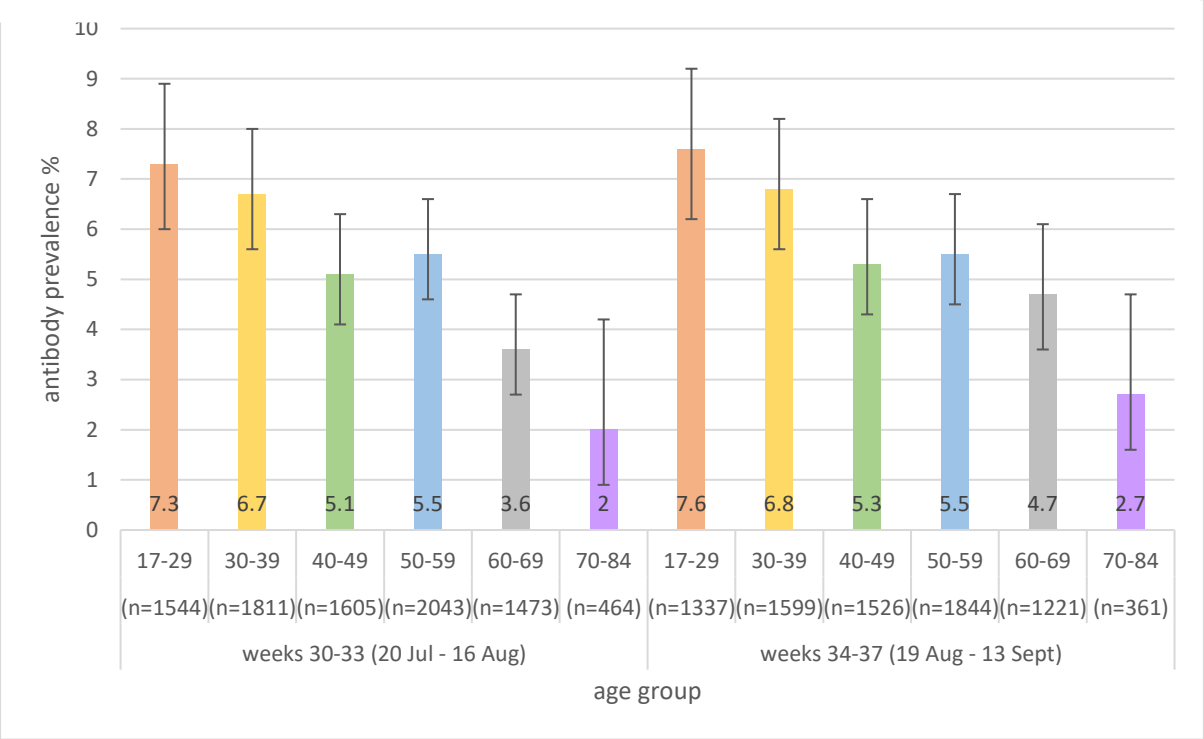
Adjusted seroprevalence in London was 10.8% (95% CrI 8.6%-13.4%) in week 37. This followed an increase to 12.6% (95% CrI 10.2%-15.3%) in week 35 compared to 8.2% (95% CrI 6.2%-10.5%) in week 33 and 8.7% (95% CrI 6.6%-11%) in week 31, although credible intervals have remained overlapping **(Figure 1, Table S1, Appendix 1)**.

More detailed analysis of precise location and demographics of the London collection, and their association with prevalence, are shown in **Appendix 2**. There was no obvious difference in terms of the age or gender of blood donors that could explain the differences between time points (**Appendix 2: Table S2a).** The most recent collection (week 37) had a slightly higher percentage of young adults than week 35.

There was a similar percentage of samples from the Inner North & Central London postcodes (E, EC, N, NW , W & WC) in week 37 compared to week 35. Inner London postcodes were less well represented in weeks 31 and 33, although a similar percentage was also seen at week 29-30 and week 18 (**Table S2a)**. Analysis of the percentage positive by grouped postcode area and time point, showed some variability over time, but the Inner London postcodes (particularly the Inner North) often showed a higher seroprevalence **(Appendix 2: Table S2b).** There was less variability between the estimated seroprevalence within London areas in week 37 compared to week 35 **(Table S2b).**

Detailed information on donor individuals, such as occupation are not available. However, given the current guidance on donation intervals (12 weeks for men and 16 weeks for women), those donating when prevalence was highest in weeks 18-22 are likely to be returning now to donate again in weeks 35-37.

Figure 2: population weighted EuroImmun % positive (with 95% CI) by age group in blood donors, weeks 30-33 and weeks 34-37

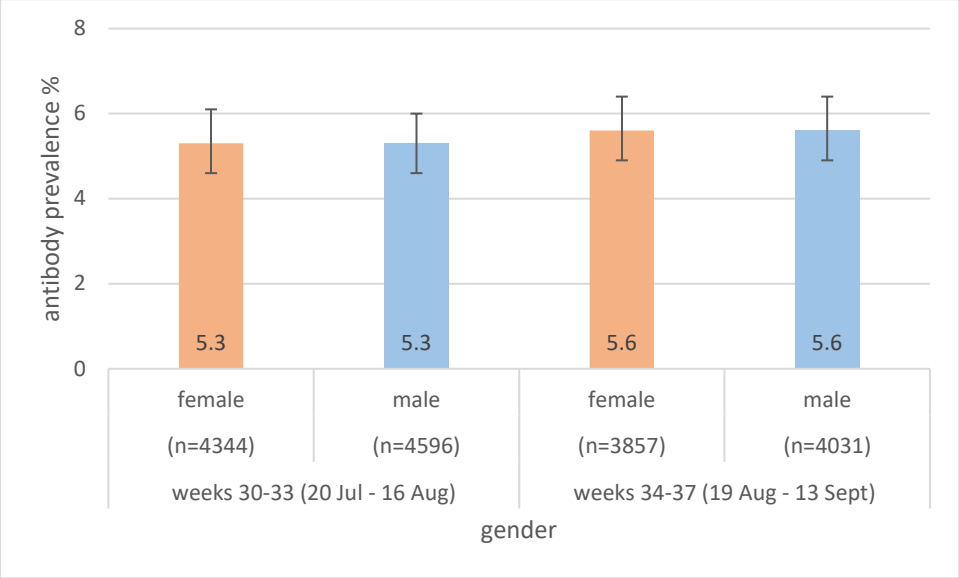


When stratified by age, the population weighted NHSBT prevalence estimates display a similar prevalence in age groups up to 50 years in weeks 34-37 compared to weeks 30-33. The previous declining prevalence with age was less evident, following increases in age groups over 50 years in weeks 34-37 **(Figure 2)**. Age trends have not remained constant over time. A higher prevalence in younger adults was observed early in the epidemic, but differences between age groups declined

during the lockdown period. For example, all age groups up to 60 years old displayed a similar prevalence in weeks 26-30 (see Summary Report 14). In weeks 32-35, the prevalence in adults aged 30-39 had increased relative to weeks 28-31, and this trend is continuing in weeks 34-37 in adults aged over 50.

There was no evidence of a difference between the genders in weeks 34-37, as was also seen in weeks 30-33 (**Figure 3**). This compares to a higher prevalence in men in week 28-31 and preceeding time points (see Summary Report 15). Prevalence by gender have also not been consistent over time, and higher prevalences in women than men were seen in the early part of the epidemic.

Figure 3: Population weighted EuroImmun % positive (with 95% CI) by gender in blood donors, weeks 30-33 and weeks 34-37



Seroprevalence in adults aged 19-64 years (SEU and RCGP collections)

As a comparison with the results from testing blood donors, two additional collections of indviduals aged 19-64 have been analysed; these are SEU residual sera from participating hospital laboratories across the country and RCGP sera collected via general practioners at the time of routine blood tests. These include 2523 samples from the SEU collected between 1st February and 8th September and 8929 samples from the RCGP collected between 16th March and 8th September and samples were tested using both the Abbott and EuroImmun assay. For the Abbott assay % pos is given as % positive or indeterminate/equivocal, with an indeterminate assay cut-off of 0.8. Using a cut off of 0.8, Abbott sensitivity is estimated to be 95.7% and specificity 99.1%.(see **Appendix 6**).

Table 2: % positive and adjusted prevalence by assay, collection and period

Colle-ction	period	weeks	pos	ind	neg	total	% pos (95% CI)	adjusted prevalence (95% CrI)
EuroImmun								
RCGP	15 Jun 24 Jul	25-30	129	18	2826	2973	4.3% (3.6% - 5.1%)	4.4% (3.3% - 5.5%)
RCGP	27 Jul 14 Aug	31-33	85	6	1121	1212	7.0% (5.6% - 8.6%)	7.6% (5.8% - 9.7%)
SEU	15 Jun 26 Jul	25-30	36	4	625	665	5.4% (3.8% - 7.4%)	5.7% (3.7% - 8.1%)
SEU	27 Jul 8 Sep	31-37	36	6	374	416	8.7% (6.1% - 11.8%)	9.7% (6.5% - 13.4%)
Abbott								
RCGP	16 Mar 1 May	12-18	9	0	204	213	4.2% (2.0% - 7.9%)	3.5% (1% - 7%)
RCGP	4 May 13 Jun	19-24	228	35	4024	4287	6.1% (5.4% - 6.9%)	5.5% (4.5% - 6.5%)
RCGP	15 Jun 24 Jul	25-30	141	30	3046	3217	5.3% (4.6% - 6.1%)	4.7% (3.6% - 5.7%)
RCGP	27 Jul 14 Aug	31-33	71	21	1116	1208	7.6% (6.2% - 9.3%)	7.1% (5.5% - 8.9%)
SEU	1 Feb 13 Mar	5-11	0	0	157	157	0.0% (0.0% - 2.3%)	0.2% (0% - 1.6%)
SEU	16 Mar 3 May	12-18	14	3	254	271	6.3% (3.7% - 9.9%)	5.7% (3% - 9.2%)
SEU	4 May 14 Jun	19-24	67	10	693	770	10.0% (8.0% - 12.3%)	9.6% (7.4% - 12.1%)
SEU	15 Jun 26 Jul	25-30	53	11	841	905	7.1% (5.5% - 8.9%)	6.5% (4.8% - 8.5%)
SEU	27 Jul 8 Sep	31-37	30	8	382	420	9.0% (6.5% - 12.2%)	8.6% (5.9% - 11.9%)

Results of testing RCGP and SEU collections using the Abbott and EuroImmun showed an increasing prevalence between March/April and May/June followed by a lower prevalence in late June/July. The most recent collection period (27 July – 8 September) shows an increase in all collections, compared to the previous month, although confidence limits remain overlapping **(Table 2)**.

Overall population weighted national estimates for working age adults using the RCGP, SEU and NHSBT collections during weeks 25-33 are shown in **Table 3:**

Table 3 Population weighted (by NHS region, age group) estimates by assay and collection, weeks 25-33

collection	weeks	pos	ind	neg	total	population weighted % pos (95% CI)
EuroImmun						
NHSBT	25-33	1051	178	15441	16670	6.3% (5.9% - 6.7%)
RCGP	25-33	208	24	3860	4092	5.9% (4.9% - 7.0%)
SEU	25-33	59	8	901	968	4.5% (3.3% - 6.3%)
Abbott						
RCGP	25-33	205	51	4059	4315	6.5% (5.5% - 7.6%)
SEU	25-33	72	18	1122	1212	5.2% (3.9% - 7.0%)

RCGP and NHSBT prevalence estimates using the NHSBT and RCGP collections were very similar, at approximately 6%. Estimates using the SEU collection were slightly lower, although sample sizes were also lower, and credible intervals were overlapping. Estimates were slightly higher using the Abbott assay than the EuroImmun assay on comparable samples groups. Further analysis of overall population weighted national estimates from the SEU and RCGP data by collection period confirmed the increase in prevalence in all collections between the earlier sample period (15 Jun-24 Jul) and the more recent collection period (27 Jul – 8 Sep) **(Appendix 4: Table S4)**. The increase was higher using the EuroImmun than Abbott assay, and may reflect a higher level of antibody waning in the Abbott assay, since it is known to be a more sensitive assay than the EuroImmun (**Appendix 6**).

Regional estimates using the three collections are shown in **Table 5:**

Table 5: Age weighted % pos by NHS Region, assay and collection, weeks 25-33. Estimates are only given where there are at least 50 samples.

	NHSBT		RCGP		SEU	
	n	age weighted % pos (95% CI)	n	age weighted % pos (95% CI)	n	age weighted % pos (95% CI)
EuroImmun assay						
EE	1921	6.3% (5.3% - 7.6%)	121	4.8% (1.5% - 14.1%)	43	
London	4287	9.3% (8.5% - 10.2%)	472	11.8% (9.1% - 15.3%)	32	
Midlands	2190	6.4% (5.4% - 7.6%)	481	6.5% (4.2% - 10.0%)	143	4.3% (1.9% - 9.6%)
NE & Y	1781	5.1% (4.1% - 6.2%)	548	2.0% (1.1% - 3.4%)	328	8.2% (5.3% - 12.4%)
NW	1715	8.0% (6.7% - 9.4%)	540	5.0% (3.1% - 7.9%)	316	7.4% (4.8% - 11.1%)
SE	2076	4.6% (3.7% - 5.6%)	649	5.2% (3.7% - 7.4%)	39	
SW	2700	3.4% (2.7% - 4.2%)	1281	3.5% (2.5% - 4.8%)	67	7.2% (2.5% - 18.8%)
Abbott assay						
EE			127	5.9% (2.3% - 14.2%)	47	
London			480	13.1% (10.2% - 16.7%)	34	
Midlands			497	5.2% (3.3% - 8.1%)	156	3.9% (1.7% - 8.5%)
NE & Y			575	3.0% (2.0% - 4.7%)	372	10.5% (7.6% - 14.3%)
NW			595	5.6% (3.7% - 8.4%)	478	7.7% (5.6% - 10.5%)
SE			692	6.4% (4.7% - 8.8%)	46	
SW			1349	4.2% (3.2% - 5.5%)	79	7.5% (3.4% - 16.0%)

Seroprevalence varies between the regions, being highest in London. Seroprevalence estimates for London were higher in the RCGP collection, than the blood donors, particularly when measured using the more sensitive Abbott assay. There was good agreement between estimates using the EuroImmun assay for some regions, in particular comparison between the RCGP and blood donors in the Midlands, the South East and the South West. In the North East and North West, however, prevalence was higher in blood donors and the SEU collection than in the RCGP collection. It should be noted that sample numbers vary by region for the RCGP and SEU collections, and there is greater uncertainty around some estimates than others **(Table 5).**

When stratified by age, the population weighted RCGP prevalence estimates were slightly lower in all age groups than in the corresponding blood donors, with the exception of the 60-65 year old age group, where prevalence was higher (**Table 6**). Prevalence was highest in the younger adults (18-29 year olds) for blood donors and slightly lower in the older working age adults, but similar prevalence levels were seen in the youngest (18-29 years) and the the oldest age group (60-65 year olds) in the RCGP collections. This may reflect inclusion of care home residents in the RCGP collection. Estimates using the SEU collection were more variable with wider confidence limits.

Table 6: Region weighted % pos by age group, assay and collection, weeks 25-33

	NHSBT		RCGP		SEU	
	n	region weighted % pos (95% CI)	n	region weighted % pos (95% CI)	n	region weighted % pos (95% CI)
EuroImmun assay						
18-29	3073	7.5% (6.6% - 8.6%)	461	6.9% (4.3% - 11.0%)	134	4.9% (2.5% - 9.5%)
30-39	3775	6.2% (5.5% - 7.1%)	695	5.1% (3.4% - 7.5%)	261	1.4% (0.5% - 3.7%)
40-49	3562	5.8% (5.1% - 6.7%)	896	5.2% (3.8% - 6.9%)	246	4.6% (2.6% - 7.9%)
50-59	4425	6.4% (5.7% - 7.2%)	1420	5.7% (4.4% - 7.4%)	225	8.1% (4.4% - 14.6%)
60-65	1835	4.0% (3.2% - 5.0%)	620	6.8% (4.9% - 9.4%)	102	2.2% (0.9% - 5.5%)
Abbott assay						
18-29			476	6.8% (4.3% - 10.5%)	329	4.3% (2.5% - 7.2%)
30-39			726	4.9% (3.3% - 7.2%)	282	3.0% (1.7% - 5.3%)
40-49			946	7.0% (5.3% - 9.2%)	257	6.4% (3.5% - 11.5%)
50-59			1495	7.0% (5.5% - 8.7%)	235	8.2% (4.5% - 14.5%)
60-65			672	7.1% (5.2% - 9.5%)	109	3.2% (1.6% - 6.5%)

RCGP Ethnicity, Deprivation and Smoking Analysis

Ethnicity information was available for 4,280 (56%) 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 during the period 15 June – 14 Aug 2020. Over the same period, IMD quintile was available for 5996 (65%) patients and smoking status was available for 2349 (15%) patients. Patients covered a wide age range from age 13 to age 97. Samples were tested for antibodies using both the Abbott and EuroImmun assays.

Results were very similar between the Abbott and EuroImmun assays, Abbott results are reported since there were more test results available. The % positive or equivocal using the Abbott assay are given in **Figures 4, 5 and 6** for ethnicity, smoking status and IMD quintile respectively. Observed antibody prevalence was highest among black ethnicities, among non-smokers, and in the most deprived quintile (quintile 1).

The concentration of the Asian and black population was higher in London and in adolescents and young adults, as well as in non-smokers and in the most deprived quintile (data not shown). To check whether the differences in prevalence by ethnicity, IMD or smoking could be explained by regional or age differences, a logistic regression model was fitted including ethnicity, IMD quintile, smoking status, NHS region and broad age group (13-29, 30-64, 65+) as explanatory variables; odds ratios (OR) are given in **(Appendix 5: Table S5)**. After adjustment for age group and region, the OR of a positive/equivocal Abbott test result was higher among all non-white ethnicities compared with white ethnicities, however this difference was only statistically significant among Black ethnicities (OR 5.2 95% CI 2.5 - 10.7) (**Table S5)**. Results for ethnicity follow similar patterns to that reported in serological surveillance summary report 13 (15th July), for an earlier period (weeks 18-25). The OR of a positive/equivocal Abbott test result was significantly lower among active smokers (OR 0.3 95% CI 0.1 - 0.6) versus non-smokers, and non-significantly lower among ex-smokers (OR 0.7 95% CI 0.5 - 1.1) **(Table S5).** Using the most deprived quintile as the reference, ratios were below 1 for quintiles 2 to 5, but only significantly so for quintile 3 (OR 0.5 95% CI 0.3 - 0.9) **(Table S5)**.

Figure 4. % positive or equivocal by ethnicity using the Abbott assay during weeks 25-33.

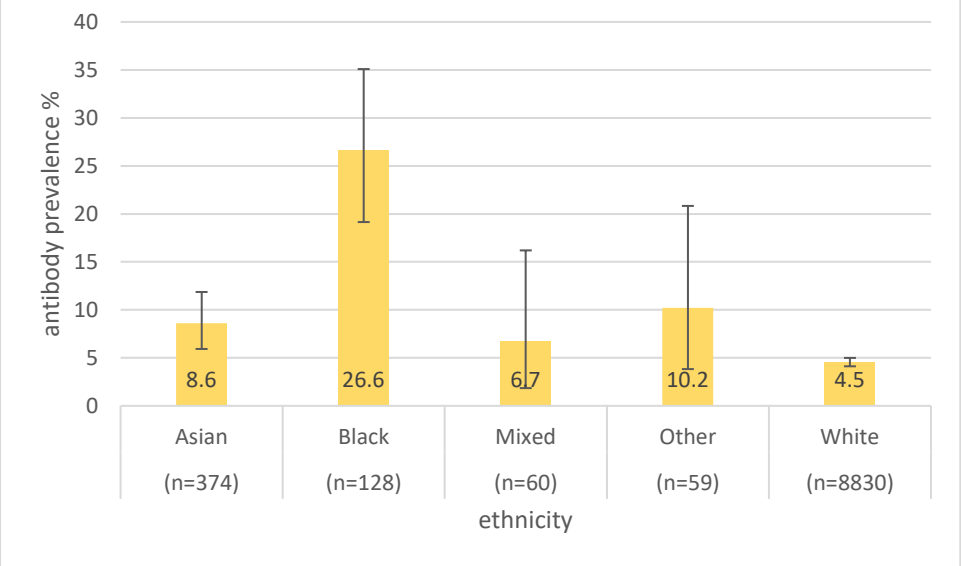


Figure 5 % positive or equivocal by smoking status using the Abbott assay during weeks 25-33.

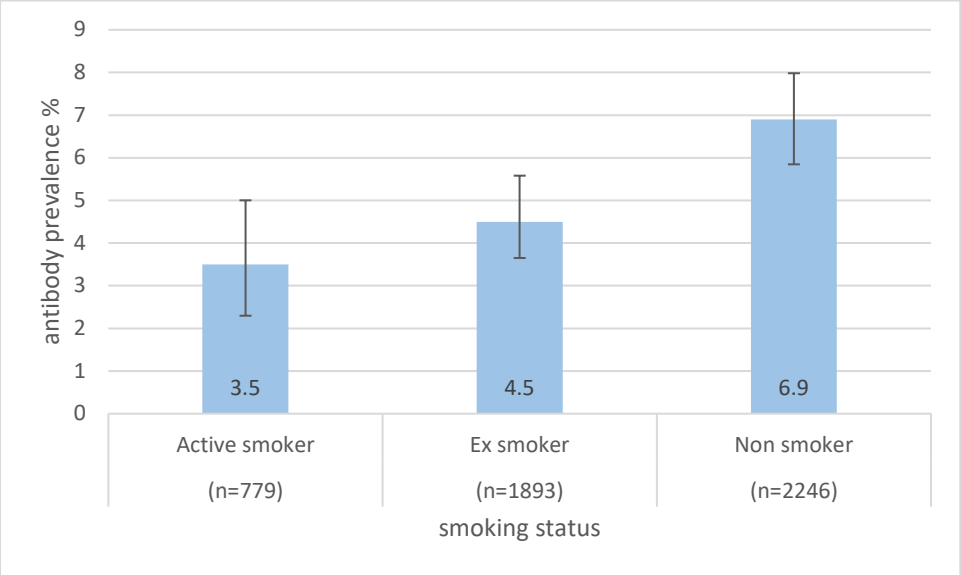
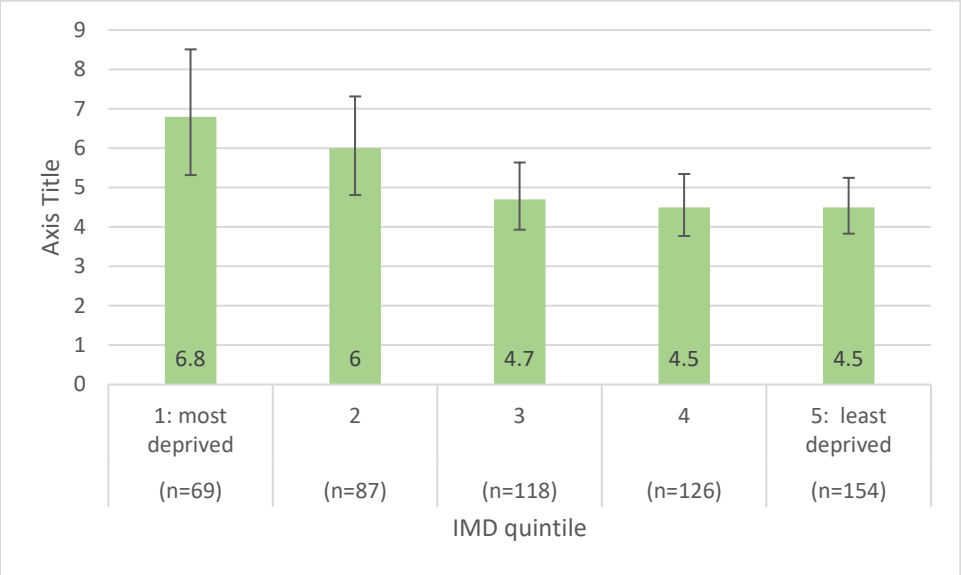


Figure 6 % positive or equivocal by IMD (index of multiple deprivation) quintile using the Abbott assay during weeks 25-33.



Comments

We report national prevalence estimates of 5.6% (95% CrI 5.1% - 6.2%) (unadjusted) or 6.1% (95% CrI 5.4% - 6.8%) after adjustment for sensitivity and specificity of the assay for the period 19th to 13th September (weeks 34-37) for adults, based on testing 7888 blood donors during this four-week period. This represents no change from the unadjusted estimate of 5.3% in the previous four weekly period and is very similar to the most recent unadjusted estimates of national prevalence from the community ONS study of 6.0% (95% CI 5.1%-7.0%) based on testing approximately 7000 adults over 16 between 26 April and 23rd August. The slightly lower estimate based on blood donor data may reflect the the samples for the ONS study have been collected over a longer time frame, including during the epidemic peak, since we have seen a general decline in prevalence over time in all collections.

Updated regional NHSBT prevalence estimates based on the results of testing the sixth set of samples from the South West and North East and Yorkshire, the 7th set from the Midlands, and the 12th set of samples from London (weeks 34-35), are presented. The South West and Midlands showed a slight increase in seroprevalence, although there were more samples from the Birmingham area, which is thought to have a higher seroprevalence, while the North East and Yorkshire showed a continuing plateauing effect. Following a large increase in estimated seroprevalence in London in week 35 to 12.6% (95% CrI 10.2% - 15.3%), the most recent collection showed a stabilisation/reduction with estimated seroprevalence at week 37 being 10.8% (95% CrI 8.6%-13.4%). This suggests that the while observed increase could in part be due to increases in recent infection, random effects and potential changes in the characteristics of the donor population over time such as the precise geographical location within London, and cohort effects, are also likely to be contributory factors. Characteristics of the donor population over time may itself been associated with lockdown imposition and easing, and individual risk of exposure. Given the current guidance on donation intervals, those donating when prevalence was highest in weeks 18-22 are likely to be returning now to donate again. There was also a reduced attendance of donors during August/potential holiday periods. Further statistical modelling to attempt to separate effects of age, within London location and time in this dataset are underway using dynamic multi regresssion post-stratification (MRP) models.

Data from routine collections among working age adults from within the Royal College of General Practioners Research and Surveillance Centre (RCGP-RSC) network and residual SEU collection is also presented. There was good agreement in national seroprevalence estimates using the RCGP and blood donor collections of around 6% for working age adults, with slightly lower estimates in the smaller SEU collection. Analysis of positivity by time suggest a recent slow increase in seroprevalence in both the RCGP and SEU collections, following a previous period of slow decline. There was also evidence of variation between regions, and age groups, that were broadly similar to the blood donor data, although estimates of seroprevalence in adults aged 60-65 years were higher in the RCGP collections. This may reflect the likely inclusion of care home residents in the RCGP collection.

Further analyses of RCGP data for all ages between 13 and 97 years demonstrated an increased seroprevalence amongst non-smokers, lower socioeconomic groups and in particular a five-fold increase amongst black ethnicities. Asian, mixed and other ethnicities also showed higher

seroprevalence compared to white ethnicities, although it was not statistically significant difference. Logistic regression confirmed these effects were independent of age and geography.

Appendix 1: NHSBT data

***Table S1**: 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%)
	17-20 Jul	29-30	86	22	956	1064	8.1% (6.5% - 9.9%)	8.9% (6.9% - 11.3%)
	30 Jul - 2 Aug	31	79	9	916	1004	7.9% (6.3% - 9.7%)	8.7% (6.6% - 11%)
	13-16 Aug	33	76	15	920	1011	7.5% (6.0% - 9.3%)	8.2% (6.2% - 10.5%)
	27-28 Aug	35	112	18	881	1011	11.1% (9.2% - 13.2%)	12.6% (10.2% - 15.3%)
	11-13 Sep	37	98	21	897	1016	9.6% (7.9% - 11.6%)	10.8% (8.6% - 13.4%)
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%)
	11-16 Jun	24-25	77	7	1040	1124	6.9% (5.4% - 8.5%)	7.4% (5.6% - 9.5%)
	10-13 Jul	28-29	65	6	995	1066	6.1% (4.7% - 7.7%)	6.5% (4.7% - 8.6%)
	6-7 Aug	32	46	8	958	1012	4.5% (3.3% - 6.0%)	4.6% (3% - 6.5%)
	3-6 Sep	36	64	14	938	1016	6.3% (4.9% - 8.0%)	6.8% (4.9% - 8.9%)
NE & Y	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%)
	8-9 Jul	28	47	4	970	1021	4.6% (3.4% - 6.1%)	4.7% (3.1% - 6.6%)
	5-6 Aug	32	48	9	937	994	4.8% (3.6% - 6.4%)	5% (3.3% - 6.9%)
	2-3 Sep	36	41	10	981	1032	4.0% (2.9% - 5.4%)	3.9% (2.4% - 5.7%)
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	98	16	894	1008	9.7% (8.0% - 11.7%)	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%)
	29-31 Jul	31	69	18	945	1032	6.7% (5.2% - 8.4%)	7.2% (5.4% - 9.4%)
	26-28 Aug	35	50	9	734	793	6.3% (4.7% - 8.2%)	6.8% (4.7% - 9.2%)

***Table S1 (cont)**: 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)
SW	24-26 Apr	17	42	8	815	865	4.9% (3.5% - 6.5%)	5% (3.2% - 7%)
	21-22 May	21	42	14	994	1050	4.0% (2.9% - 5.4%)	4% (2.5% - 5.7%)
	19–22 Jun	25-26	38	4	970	1012	3.8% (2.7% - 5.1%)	3.7% (2.2% - 5.4%)
	17-20 Jul	29-30	25	10	1017	1052	2.4% (1.5% - 3.5%)	1.9% (0.6% - 3.4%)
	13-14 Aug	33	32	13	981	1026	3.1% (2.1% - 4.4%)	2.9% (1.5% - 4.4%)
	9-11 Sep	37	37	8	965	1010	3.7% (2.6% - 5.0%)	3.5% (2.1% - 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%)
	24 Jul	30	38	13	967	1018	3.7% (2.7% - 5.1%)	3.6% (2.2% - 5.3%)
	19-21 Aug	34	38	7	962	1007	3.8% (2.7% - 5.1%)	3.7% (2.2% - 5.4%)
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%)
	25-28 Jul	30-31	66	9	1001	1076	6.1% (4.8% - 7.7%)	6.6% (4.8% - 8.6%)
	21-24 Aug	34-35	44	15	944	1003	4.4% (3.2% - 5.8%)	4.4% (2.8% - 6.3%)
Welsh blood service								
Wales		17	34	4	968	1006	3.4% (2.4% - 4.7%)	3.2% (1.8% - 4.8%)

Appendix 2: Detailed NHSBT data for London

***Table S2a**: Demographic data for NHSBT collections from London by period of sampling and detailed location : number of samples (& percentage of collection)*

week of collection	13	15-16	18	21	23-24	25-26	27-28	29-30	31	33	35	37
by age group:												
17-29	193 (26%)	286 (26%)	226 (23%)	184 (23%)	271 (25%)	194 (21%)	252 (23%)	230 (22%)	237 (24%)	253 (25%)	210 (21%)	277 (27%)
30-39	197 (26%)	279 (26%)	258 (26%)	210 (26%)	272 (25%)	215 (24%)	255 (24%)	285 (27%)	254 (25%)	273 (27%)	259 (26%)	289 (28%)
40-49	135 (18%)	192 (18%)	195 (20%)	152 (19%)	179 (16%)	162 (18%)	183 (17%)	181 (17%)	135 (13%)	166 (16%)	175 (17%)	183 (18%)
50-59	164 (22%)	217 (20%)	187 (19%)	153 (19%)	230 (21%)	209 (23%)	224 (21%)	199 (19%)	184 (18%)	174 (17%)	202 (20%)	158 (16%)
60-69	67 (9%)	111 (10%)	105 (11%)	98 (12%)	141 (13%)	131 (14%)	132 (12%)	117 (11%)	141 (14%)	103 (10%)	129 (13%)	92 (9%)
70+	1 (0%)	0 (0%)	3 (0%)	0 (0%)	1 (0%)	0 (0%)	33 (3%)	52 (5%)	53 (5%)	42 (4%)	36 (4%)	17 (2%)
by sex:												
F	357 (47%)	489 (45%)	526 (54%)	391 (49%)	533 (49%)	479 (53%)	513 (48%)	522 (49%)	516 (51%)	516 (51%)	469 (46%)	515 (51%)
M	400 (53%)	596 (55%)	448 (46%)	406 (51%)	561 (51%)	432 (47%)	566 (52%)	542 (51%)	488 (49%)	495 (49%)	542 (54%)	501 (49%)
by postcode areas:												
Inner North E EC N NW W WC	191 (25%)	275 (25%)	337 (35%)	186 (23%)	254 (23%)	180 (20%)	193 (18%)	370 (35%)	277 (28%)	208 (21%)	363 (36%)	354 (35%)
Inner South SE SW	217 (29%)	329 (30%)	318 (33%)	178 (22%)	333 (30%)	187 (21%)	302 (28%)	191 (18%)	288 (29%)	332 (33%)	214 (21%)	267 (26%)
Outer North EN IG RM UB HA WD	202 (27%)	199 (18%)	154 (16%)	160 (20%)	119 (11%)	151 (17%)	199 (18%)	155 (15%)	205 (20%)	219 (22%)	217 (21%)	155 (15%)
Outer South DA BR CR SM KT TW TN	138 (18%)	269 (25%)	161 (17%)	269 (34%)	368 (34%)	379 (42%)	370 (34%)	337 (32%)	204 (20%)	243 (24%)	215 (21%)	239 (24%)
Outside London	9 (1%)	13 (1%)	4 (0%)	4 (1%)	20 (2%)	14 (2%)	15 (1%)	11 (1%)	30 (3%)	9 (1%)	2 (0%)	1 (0%)

***Table S2b**: % pos by period of sampling and detailed geographic locations, London*

week	postcode	pos	ind	neg	total	% pos (95% CI)
13	Inner North E EC N NW W WC	6	2	183	191	3.1% (1.2% - 6.7%)
	Inner South SE SW	7	2	208	217	3.2% (1.3% - 6.5%)
	Outer North EN IG RM UB HA WD	5	2	195	202	2.5% (0.8% - 5.7%)
	Outer South DA BR CR SM KT TW TN	3	5	130	138	2.2% (0.5% - 6.2%)
15-16	Inner North E EC N NW W WC	41	4	230	275	14.9% (10.9% - 19.7%)
	Inner South SE SW	29	5	295	329	8.8% (6.0% - 12.4%)
	Outer North EN IG RM UB HA WD	14	1	184	199	7.0% (3.9% - 11.5%)
	Outer South DA BR CR SM KT TW TN	22	4	243	269	8.2% (5.2% - 12.1%)
18	Inner North E EC N NW W WC	43	8	286	337	12.8% (9.4% - 16.8%)
	Inner South SE SW	38	2	278	318	11.9% (8.6% - 16.0%)
	Outer North EN IG RM UB HA WD	26	0	128	154	16.9% (11.3% - 23.8%)
	Outer South DA BR CR SM KT TW TN	19	0	142	161	11.8% (7.3% - 17.8%)
21	Inner North E EC N NW W WC	37	5	144	186	19.9% (14.4% - 26.4%)
	Inner South SE SW	22	5	151	178	12.4% (7.9% - 18.1%)
	Outer North EN IG RM UB HA WD	17	7	136	160	10.6% (6.3% - 16.5%)
	Outer South DA BR CR SM KT TW TN	33	3	233	269	12.3% (8.6% - 16.8%)
23-24	Inner North E EC N NW W WC	45	4	205	254	17.7% (13.2% - 23.0%)
	Inner South SE SW	50	3	280	333	15.0% (11.4% - 19.3%)
	Outer North EN IG RM UB HA WD	16	0	103	119	13.4% (7.9% - 20.9%)
	Outer South DA BR CR SM KT TW TN	31	1	336	368	8.4% (5.8% - 11.7%)
25-26	Inner North E EC N NW W WC	22	3	155	180	12.2% (7.8% - 17.9%)
	Inner South SE SW	29	4	154	187	15.5% (10.6% - 21.5%)
	Outer North EN IG RM UB HA WD	14	3	134	151	9.3% (5.2% - 15.1%)
	Outer South DA BR CR SM KT TW TN	39	2	338	379	10.3% (7.4% - 13.8%)
27-28	Inner North E EC N NW W WC	23	2	168	193	11.9% (7.7% - 17.3%)
	Inner South SE SW	29	5	268	302	9.6% (6.5% - 13.5%)
	Outer North EN IG RM UB HA WD	15	2	182	199	7.5% (4.3% - 12.1%)
	Outer South DA BR CR SM KT TW TN	26	2	342	370	7.0% (4.6% - 10.1%)
29-30	Inner North E EC N NW W WC	34	10	326	370	9.2% (6.4% - 12.6%)
	Inner South SE SW	20	4	167	191	10.5% (6.5% - 15.7%)
	Outer North EN IG RM UB HA WD	11	3	141	155	7.1% (3.6% - 12.3%)
	Outer South DA BR CR SM KT TW TN	20	5	312	337	5.9% (3.7% - 9.0%)
31	Inner North E EC N NW W WC	22	4	251	277	7.9% (5.0% - 11.8%)
	Inner South SE SW	21	3	264	288	7.3% (4.6% - 10.9%)
	Outer North EN IG RM UB HA WD	20	0	185	205	9.8% (6.1% - 14.7%)
	Outer South DA BR CR SM KT TW TN	15	2	187	204	7.4% (4.2% - 11.8%)
33	Inner North E EC N NW W WC	12	4	192	208	5.8% (3.0% - 9.9%)
	Inner South SE SW	28	6	298	332	8.4% (5.7% - 12.0%)
	Outer North EN IG RM UB HA WD	14	1	204	219	6.4% (3.5% - 10.5%)
	Outer South DA BR CR SM KT TW TN	21	4	218	243	8.6% (5.4% - 12.9%)
35	Inner North E EC N NW W WC	48	9	306	363	13.2% (9.9% - 17.1%)
	Inner South SE SW	23	2	189	214	10.7% (6.9% - 15.7%)
	Outer North EN IG RM UB HA WD	27	2	188	217	12.4% (8.4% - 17.6%)
	Outer South DA BR CR SM KT TW TN	14	5	196	215	6.5% (3.6% - 10.7%)
37	Inner North E EC N NW W WC	38	8	308	354	10.7% (7.7% - 14.4%)
	Inner South SE SW	23	6	238	267	8.6% (5.5% - 12.6%)
	Outer North EN IG RM UB HA WD	14	3	138	155	9.0% (5.0% - 14.7%)
	Outer South DA BR CR SM KT TW TN	23	4	212	239	9.6% (6.2% - 14.1%)

Appendix 3: Detailed NHSBT data for London

***Table S3**: Demographic data for NHSBT collections from London by period of sampling and detailed location : number of samples (& percentage of collection)*

week of sampling	14	17	20	24-25	28-29	32	36
by age group							
17-29	147 (16%)	182 (17%)	94 (11%)	165 (15%)	141 (13%)	141 (14%)	160 (16%)
30-39	170 (19%)	212 (20%)	182 (21%)	165 (15%)	164 (15%)	192 (19%)	209 (21%)
40-49	187 (20%)	238 (23%)	203 (23%)	254 (23%)	213 (20%)	200 (20%)	205 (20%)
50-59	265 (29%)	257 (25%)	228 (26%)	292 (26%)	260 (24%)	232 (23%)	251 (25%)
60-69	147 (16%)	154 (15%)	163 (19%)	248 (22%)	189 (18%)	182 (18%)	144 (14%)
70+	0 (0%)	0 (0%)	0 (0%)	0 (0%)	99 (9%)	65 (6%)	47 (5%)
by postcode area							
Outside region	5 (1%)	3 (0%)	3 (0%)	8 (1%)	2 (0%)	5 (0%)	0 (0%)
B Birmingham	159 (17%)	373 (36%)	99 (11%)	211 (19%)	297 (28%)	84 (8%)	177 (17%)
CV Coventry	298 (33%)	171 (16%)	176 (20%)	17 (2%)	118 (11%)	139 (14%)	156 (15%)
E Mids NN DE NG LN PE	136 (15%)	174 (17%)	156 (18%)	295 (26%)	304 (29%)	277 (27%)	263 (26%)
LE Leicester	79 (9%)	107 (10%)	153 (18%)	246 (22%)	178 (17%)	157 (16%)	94 (9%)
W Mids ST TF DY WR HR WS WV GL SY	239 (26%)	215 (21%)	283 (33%)	347 (31%)	167 (16%)	350 (35%)	326 (32%)
by gender							
F	442 (48%)	510 (49%)	459 (53%)	540 (48%)	557 (52%)	469 (46%)	546 (54%)
M	474 (52%)	533 (51%)	411 (47%)	584 (52%)	509 (48%)	543 (54%)	470 (46%)

Appendix 4: Population weighted seroprevalence estimates using SEU & RCGP collections

Table S4: Population weighted (by NHS region, age group) estimates by assay, collection and period

Collection	period	weeks	pos	ind	neg	total	population weighted % pos (95% CI)	population weighted modelled adjusted prevalence (95% CrI)
EuroImmun								
RCGP	15 Jun 24 Jul	25-30	125	18	2751	2894	5.0% (3.9% - 6.3%)	5.4% (4.3% - 6.7%)
RCGP	27 Jul 14 Aug	31-33	83	6	1109	1198	6.6% (5.1% - 8.5%)	7.9% (5.9% - 11%)
SEU	15 Jun 26 Jul	25-30	36	4	625	665	4.2% (2.7% - 6.4%)	5.7% (3.4% - 8.6%)
SEU	27 Jul 8 Sep	31-37	36	6	374	416	8.7% (6.5% - 11.6%)	9.5% (6.3% - 13.5%)
Abbott								
RCGP	15 Jun 24 Jul	25-30	135	30	2956	3121	5.7% (4.6% - 7.0%)	5% (4% - 6.2%)
RCGP	27 Jul 14 Aug	31-33	70	21	1103	1194	7.1% (5.5% - 9.1%)	6.8% (5.1% - 9.4%)
SEU	15 Jun 26 Jul	25-30	53	11	841	905	5.9% (3.9% - 8.7%)	4.9% (3.2% - 6.9%)
SEU	27 Jul 8 Sep	31-37	30	8	382	420	6.8% (4.6% - 10.0%)	6.5% (4% - 9.7%)

Appendix 5: Regression analyses for ethnicity, smoking status and deprivation and RCGP data

Table S5: Odds ratio estimates given by a logistic regression of positive or equivocal Abbott test result on region, age group and ethnicity. RCGP-RSC data, weeks 25-33.

	odds ratio (95% CI)
NHS Region	
London	1 (ref)
East of England	0.9 (0.4 - 2)
Midlands	0.7 (0.4 - 1.3)
North East and Yorkshire	0.5 (0.3 - 1)
North West	0.8 (0.4 - 1.4)
South East	0.8 (0.5 - 1.5)
South West	0.5 (0.3 - 1)
age group	
11-29	1.2 (0.7 - 2)
30-64	1 (ref)
65+	0.7 (0.5 - 0.9)
ethnicity	
White	1 (ref)
Asian	1.3 (0.7 - 2.5)
Black	5.2 (2.5 - 10.7)
Mixed	2 (0.5 - 9.1)
Other	3.2 (0.9 - 11.2)
missing	1.2 (0.9 - 1.8)
IMD deprivation quintile	
1: most deprived	1 (ref)
2	0.8 (0.5 - 1.3)
3	0.5 (0.3 - 0.9)
4	0.8 (0.5 - 1.4)
5: least deprived	0.6 (0.4 - 1)
smoking status	
active smoker	0.3 (0.1 - 0.6)
ex-smoker	0.7 (0.5 - 1.1)
non-smoker	1 (ref)
missing	0.7 (0.5 - 0.9)

Appendix 6: Sensitivity & Specificity

Data on testing of convalescent and baseline sera as used to estimate sensitivity and specifity (Table S6). Sensitivity is based solely on convalescent sera in the period 3 to 6 weeks post infection, this is when antibody responses appear to peak. For Abbott adjustments 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 S6. Data used in sensitivity and specificity adjustments.

	Assay	Positive	Equivocal	Negative	Total	adjustment cut-off	
							sensitivity
convalescent sera 3-6 weeks post infection	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)
							specificity
baseline sera	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)

Appendix 7: 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.

Appendix 7 References

Diggle PJ. Estimating prevalence using an imperfect test. Epidemiology Research International, 2011, ArticleID 608719.

Lewis FI and Torgerson PR. A tutorial in estimating the prevalence of disease in humans and animals in the abcence of a gold standard diagnostic. Emerg Themes Epidemiol, 2012, 9: 9.

StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP.

STATA Survey Data Reference Manual. Stata Press, 2019. ISBN-13: 978-1-59718-298-1. https://www.stata.com/bookstore/survey-data-reference-manual/ (pages 62-65)

NIMBLE Development Team. 2020. NIMBLE: MCMC, Particle Filtering, and Programmable Hierarchical Modeling. doi: 10.5281/zenodo.1211190. R package version 0.9.1, https://cran.r-project.org/package=nimble.

Park DK, Gelman A and Bafumi J. Bauesian multilevel estimation with poststratification: state level estimates from national polls. Political analysis, 2004, 12:375-385.

Bob Carpenter, Andrew Gelman, Matthew D. Hoffman, Daniel Lee, Ben Goodrich, Michael Betancourt, Marcus Brubaker, Jiqiang Guo, Peter Li, and Allen Riddell. 2017. Stan: A probabilistic programming language. Journal of Statistical Software 76(1). DOI 10.18637/jss.v076.i01

Stan Development Team. 2018. RStan: the R interface to Stan. R package version 2.17.3. http://mc-stan.org

Office for National Statistics. 2019. Population estimates by output areas, electoral, health and other geographies, England and Wales: mid-2018. https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/annualsmallareapopulationestimates/mid2018