Impact of COVID-19 vaccination programme on seroprevalence in blood donors in England, 2021

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Abstract

The COVID-19 vaccination programme commenced in the UK on 8th December 2020 primarily based on age; by 7th March 2021 approximately 93% of the English population aged 70+ years had received at least 1 dose of either the Pfizer BioNTech or AstraZeneca vaccines. Using a nucleoprotein assay that detects antibodies following natural infection only and a spike assay that detects both infection and vaccine-induced responses, we aim to describe the impact of vaccination on SARS-CoV-2 antibody prevalence in English blood donors.

Article

England introduced a mass vaccination programme against COVID-19 on 8th December 2020 primarily based on age, starting with those over 80 years of age, along with patient-facing health and social care workers, followed with prioritisation by decreasing 5-year age bands [1]. Since the beginning of the programme to 7th March 2021 over 19 million individuals in England have been vaccinated with at least one dose of vaccine: either Pfizer BioNTech (from 8th December) or AstraZeneca (from 4th January) [2]. Our aim is to describe the impact of vaccination rollout on antibody prevalence in blood donors in England.

As part of the monitoring of COVID-19 infection in England, Public Health England, in collaboration with the National Health Service Blood and Transplant Service (NHSBT) has arranged regular collections of plasma to be sent from blood donors for COVID serology testing; results are reported weekly [3]. Since 7th October 2020 approximately 250 samples have been collected each week from each of the seven NHS regions: East of England, London, Midlands, North East and Yorkshire, North West, South East, South West; prior to this date 1000 samples were collected from two of the seven regions per week on a 4-week cycle. Here we present national seropositivity estimates on the Roche S (spike) assay from 24th August 2020 onward, which generally covers the period of the second epidemic wave and vaccination rollout, and national seropositivity estimates on the Roche N (nucleoprotein) assay from 30th November onward, which covers the period of vaccine rollout and the peak of England's B.1.1.7-variant dominated epidemic wave [4].

Nucleoprotein assays (Roche N) only detect antibodies post natural infection, whereas spike assays (Roche S) detect both post natural infection and vaccine-induced antibodies. Thus, changes in seropositivity for the Roche N assay will reflect natural infection acquisition. Increases in seropositivity as measured by S antibody will reflect both natural infection and vaccine induced antibodies. Antibody responses to both targets will reflect

infection/vaccination occurring at least two to three weeks previously given the time taken to generate a SARS-CoV2 antibody response.

Seropositivity estimates are calculated on a 4-week rolling basis and are population weighted by NHS region, age group and sex. Estimates are not adjusted for assay sensitivity and specificity, which are estimated at sensitivity 97.2% (95% CI 95.4-98.4%) and specificity 99.8% (95% CI 99.3-100%) for the Roche N [5], and the manufacturer claims sensitivity 14+ days post-infection 98.8% (95% CI 98.1-99.3%) and specificity 99.98% (95% CI 99.91–100%) for the Roche S [6].

National antibody prevalence estimates

7001 samples were available during the most recent 4-week period 8th February–7th March 2021, of which 2295/7001 were Roche S positive and 1011/6998 were Roche N positive. Overall population weighted seropositivity among blood donors was 37.7% (95% CI 36.5% - 38.9%) using the Roche S assay (Figure 1). This continues to be part of an increasing trend that has accelerated since mid-December. It takes 2-3 weeks to produce an antibody response, so by 8th February a full 9 weeks had elapsed since the start of the national vaccine programme, and the Roche S assay would be expected to be detecting vaccine induced antibodies [7]. This is evidenced by diverging trend between the Roche N and Roche S seropositivity (Figure 1) and the considerably lower Roche N seropositivity that reflects a natural infection prevalence of 14.8% (95% CI 13.9% - 15.7%) over the same period.

Our national seropositivity estimates based on the Roche S assay of 23.6% (95% CI 22.5% - 24.8%) and 37.7% (95% CI 36.5% - 38.9%) for the periods 18th January – 14th February and 8th February–7th March respectively, compare with 23.3% (95% CI 22.7% - 23.9%) and 34.6% (95% CI 34.0% - 35.3%) from the UK Office of National Statistics Infection Survey for the periods 15th January – 11th February and 4th February – 3rd March respectively, based on

a single S target based assay [8, 9]. These estimates are higher than the seropositivity of 13.9% (95% CI 13.7% - 14.1%) found by the REACT survey using self-administered lateral flow testing over the period 26th January – 8th February 2021 [10].

Antibody prevalence by age group over time

When stratified by age, based on results from the Roche S assay for the most recent 4-week period, the population weighted antibody prevalence was highest in the age 70-84 group at 75.8% (95% CI 71.2% - 79.9%) (Figure 2). Seroprevalence has been clearly increasing across all age groups from survey weeks 7th December 2020 – 3rd January 2021. It should be noted that blood donor cohorts under age 50 were seeing increases prior to this which reflect higher transmission.

In parallel, the Roche N assay, a marker for natural infection, showed not only the lowest seroprevalence in the age 70-84 blood donor cohort in the most recent survey weeks at 5.6% (95% CI 3.7% - 8.5%), but this also stabilised over successive four week intervals; for example over the period 1st-31st January 2021 seropositivity was 5.2% (95% CI 3.1% - 8.5%) as shown in Figure 2. Seropositivity based on Roche N was highest in the youngest blood donor cohort and continues to increase. The seropositivity estimate for this group was 22.8% (95% CI 20.3% - 25.6%) over the most recent period (8th February–7th March 2021) compared with 16.4% (95% CI 14.2% - 18.8%) over the period 1st–31st January 2021. Other age groups also show rises in seropositivity from the N assay suggesting ongoing transmission.

Taking the Roche S and N results together, this is suggestive of vaccine impact effects in the vaccine eligible age 70+ cohort. The seroprevalence for the most recent period reflects vaccination at least 2-3 weeks prior, allowing time for antibodies to develop and be detected. For the 70-84 age group, the increase in S positive N negative outcomes accelerated from

survey weeks 11th January – 7th February 2021 as shown together with uptake in Figure 3. Going back to the week ending 7th February, uptake was 76.3%, which roughly corresponds with the most recent 4-week period (Figure 3). Note that blood donation in those aged 70+ tails off with age, and the cumulative vaccine uptake in those aged 70+ is weighted by the donor age distribution.

The population vaccine uptake of 8.7% to the week ending 7th February in those 18-59y (Figure 3) is lower than S positive N negative donor seroprevalence in younger blood donors (Figure 2), suggesting that health and social care workers are over-represented in the latter group.

Discussion

The vaccination status of donors in our survey is not readily available but parallel testing using a nucleoprotein and a spike assay allows us to monitor continuing trends in transmission and vaccine-induced seropositivity in this population. Since the commencement of vaccine rollout Roche S seropositivity has increasingly risen above Roche N seropositivity and clearly shows trends in vaccine-induced antibodies; this is especially true in the 70-84 year age group who were among the first to be targeted for vaccination. Meanwhile Roche N seropositivity in this age group has remained stable, suggestive of vaccine impact. This adds to a growing body of evidence suggestive of vaccine impact in the UK population [11].

Due to the speed of the vaccine roll out, by 7th March 2021 vaccine uptake was estimated at 73.5% among ages 60-69 and 92.8% among ages 70-84. Hence further increases in the seroprevalence of the 60-69y and 70-84y cohorts are expected to follow.

Figure 1: *National SARS-CoV-2 antibody seropositivity in English blood donors weighted by NHS region, sex and age group, using Roche S and N assays, rolling four weekly average.*

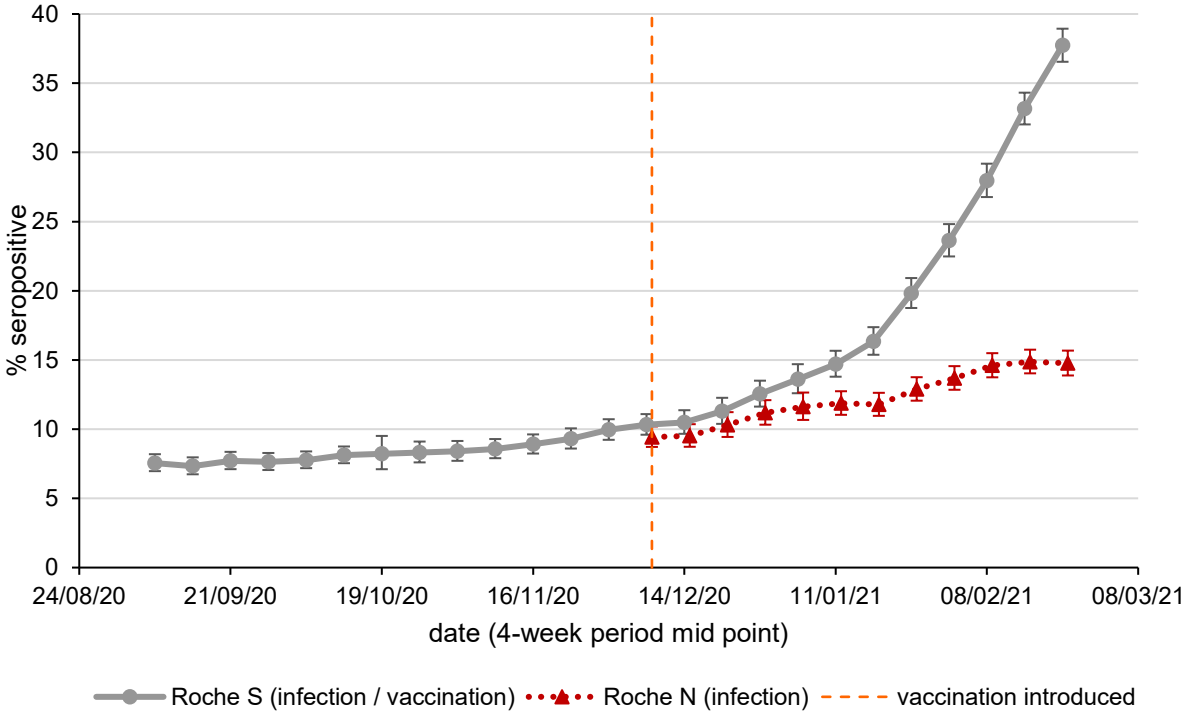


Figure 2: *SARS-CoV-2 antibody seropositivity based on the Roche S assay (S+, grey solid lines), the Roche N assay (N+, red dotted lines) in English blood donors by age group, weighted by NHS region and sex, rolling four weekly average from the 4 week period 25/11/2020 - 20/12/2020 to the 4 week period 08/02/2021 – 07/03/2021. Also shown is the percentage Roche S seropositive, Roche N seronegative (S+N-, blue dashed lines).*

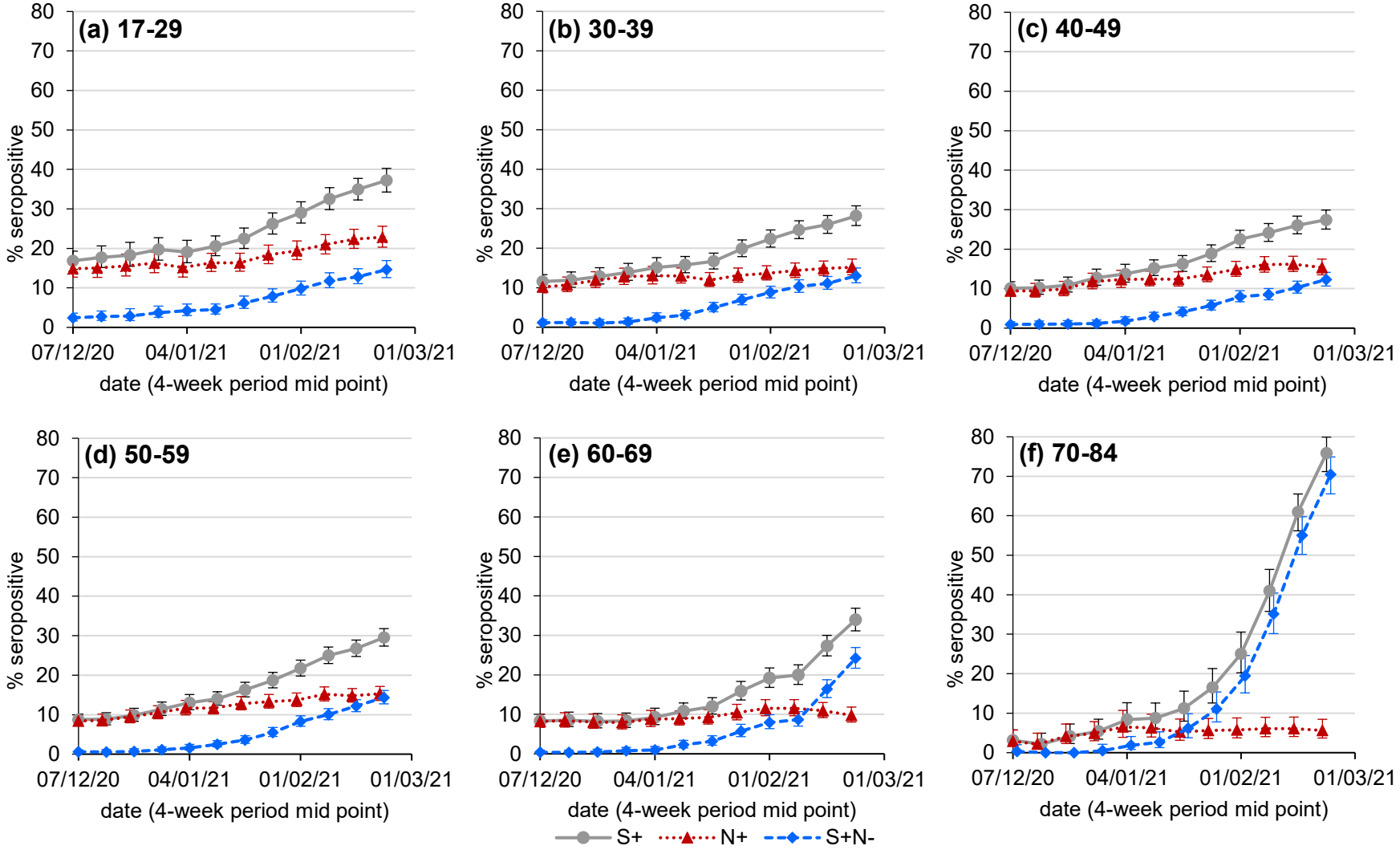
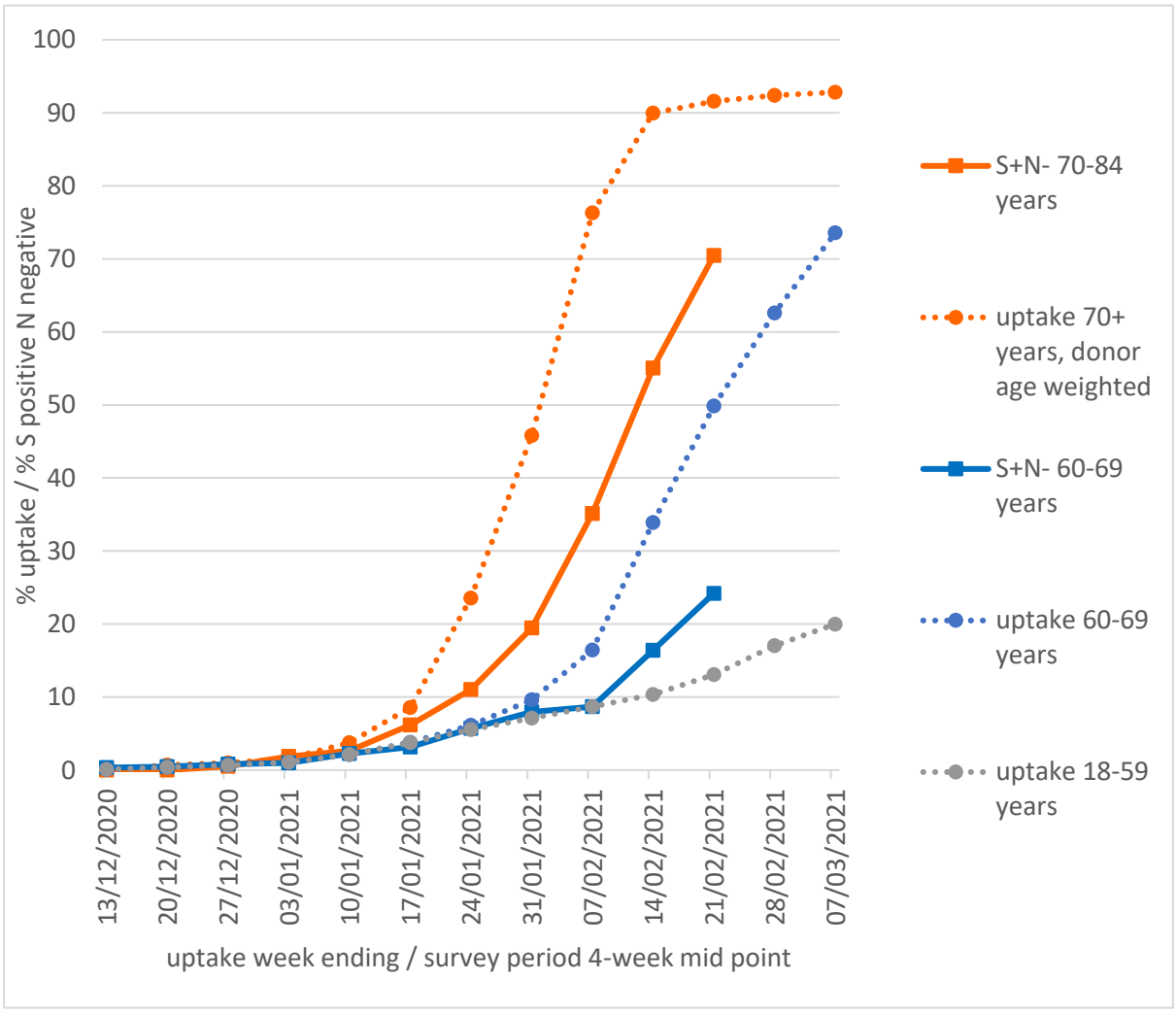


Figure 3 *Cumulative dose 1 COVID-19 vaccine uptake by age group (age on 31/03/2021), vaccine uptake is calculated using the National Immunisation Management System (NIMS), a new national vaccine register in England. The NIMS dataset facilitates management of the vaccination programme and is a database of named individuals registered with the NHS and is used to contact and invite people for vaccination. Roche S positive, N negative is plotted for the 70-84 and 60-69 age groups to demonstrate the lag in antibody response. Age 70+ uptake is weighted by the 70-84 donor age distribution.*



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Conflict of Interest

EL reports the Public Health England Vaccine Evaluation Unit performs contract research on behalf of GSK, Sanofi and Pfizer which is outside the submitted work.

HW, SE, IH, SR, KB, GA, EC, AL, CT, CC, IH, SR, JH, CR, AO, TB, MR report no conflicts of interest.

Author's contributions

HW, SE, IH, SR, KB and GA wrote the manuscript, with input from MR. HW performed statistical analysis. EC, AL, CT, CC collated vaccine uptake statistics. EL, IH, SR, JH managed serology data. CR, AO, TB performed the testing. All authors read and approved the submission.

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