



## Supplementary Materials for

### **Title: Resurgence of SARS-CoV-2: detection by community viral surveillance**

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#### **This PDF file includes:**

Materials and Methods  
Figs. S1 to S6  
Tables S1 to S7  
Captions for Data S

#### **Other Supplementary Materials for this manuscript include the following:**

Data S1 to Sx [paste data table titles in a list]

## Materials and Methods

The REACT study program includes REACT-1 and has been described elsewhere (*13*). Briefly, in REACT-1, we invited randomly selected individuals aged five years and over from the National Health Service (NHS) list of patients registered with a general practitioner, among the 315 lower-tier local authorities (LTLAs) in England (317 are listed but we merge the Isles of Scilly with Cornwall and the City of London with Westminster). Four rounds of data collection were completed between 1st May and 8th September 2020 (Table 1). Among those registering to take part, in addition to age, sex, address and postcode available from the NHS register, we obtained, by online or telephone questionnaire, information on e.g. key worker status, ethnicity, smoking, household size, contact with known or suspected COVID-19 cases, hospital contacts, and symptoms. We provided written and video instructions to obtain a self-administered throat and nose swab (administered by parent or guardian for children aged 5 to 12 years).

To obtain information about symptoms, we asked specifically if participants had one or more of a list of respiratory symptoms (27 for round 1, 29 for rounds 2, 3 and 4) and then we asked when they had experienced those symptoms. The symptom questions changed slightly after round 1, but were the same for rounds 2, 3 and 4. In round 1, we asked if the participant had experienced symptoms and then we asked the month in which they had occurred. If participants had experienced symptoms, we then asked if any of those symptoms had occurred in the past week. However, we did not ask which of those symptoms had occurred in the last week. Therefore, for round 1, when participants reported classic and non-classic COVID-19 symptoms at some time and any symptom in the last week, we could not be sure that it was a classic COVID-19 symptom: we classified those participants as not having classic COVID-19 symptoms in the past week. In rounds 2, 3 and 4, we asked specifically which symptoms occurred in the week prior to the day of the swab. We did not follow up participants to see if they later developed symptoms. Some participants had already had a positive test when they took an additional test for REACT-1.

In each round swab results were obtained from between 120,000 and 160,000 people giving a combined total of ~594,000 participants (Table 1). During the first round of data collection (1st May to 1st June 2020), swabs were initially collected in viral transport medium and sent to one of four Public Health England (PHE) laboratories for processing (n = 8,595 swabs with reported

result). All subsequent collections were obtained using dry swabs; participants were requested to refrigerate these before courier pick-up the same or next day. Swabs were then delivered to a commercial laboratory on a cold chain (4° to 8° C) to maintain sample integrity.

Samples were tested by reverse-transcription--polymerase-chain-reaction (RT-PCR) with two gene targets (E gene and N gene). We assessed cycle threshold (CT) values as a proxy for intensity of viral load across the four surveys and defined a swab to be positive if both gene targets were positive or if N gene was positive with CT value less than 37.

### Analyses

We used an exponential model of growth or decay to investigate trends in swab positivity over time assuming that the number of positive samples each day (out of the total number of samples each day) arose from a binomial distribution. The model then takes the form  $I(t) = I_0 e^{rt}$ , where  $I(t)$  is the swab positivity at time  $t$ ,  $I_0$  is the initial swab positivity on the first day of the round and  $r$  is the growth rate. The binomial likelihood for  $P$  positives out of  $N$  tests on a given day is then  $P \sim B(N, I_0 e^{rt})$ . We used day of swabbing or, if unavailable, day of collection. We obtained posterior credible intervals using a bivariate No-U-Turn sampler assuming uniform prior distributions on  $I_0$  and  $r$  (43). To estimate the reproduction number  $R$ , we assumed a generation time following a gamma distribution with a shape parameter,  $n$ , of 2.29 and a rate parameter,  $\beta$ , of 0.36 (corresponding to a mean generation time of 6.29 days) (30). The reproduction number was then calculated using the equation  $R = (1 + \frac{r}{\beta})^n$  (44). We analysed  $R$  using data from two sequential rounds and separately for each round. We also fit an analogous model to the publicly available case surveillance data (45) in which we assumed that the number of cases on a given day followed a negative binomial distribution with a single dispersion parameter for all days that the model is being fitted to. We estimated the dispersion parameter as an additional fitted parameter of the model with a uniform prior distribution and bounded above 0.

We fit a Bayesian penalised-spline (p-spline) model (46) to the daily data using a No U-Turns Sampler in logit space. We split the data into segments of approximately 5 days by regularly

spaced knots, with further knots defined beyond the period of the study in order to remove edge effects. We defined a system of 4th order basis-splines (b-splines) over the knots and the model consisted of a linear combination of these b-splines. We guarded against overfitting through the inclusion of a second-order random-walk prior distribution on the coefficients of the b-splines.

This prior distribution takes the form  $b_i = 2b_{i-1} - b_{i-2} + u_i$ , where  $b_i$  is the  $i^{th}$  b-spline coefficient and  $u_i$  is normally distributed with  $u_i \sim N(0, \rho^2)$ . The prior distribution assumes a constant first derivative and so penalises against any changes in the growth rate unless it is significantly supported by the data. The amount of which changes in the growth rate are penalised are controlled by the parameter  $\rho$  that we give an inverse gamma prior distribution;  $\rho \sim IG(0.001, 0.001)$ . We assume a uniform prior distribution on the first two b-spline coefficients,  $b_1$  and  $b_2 \sim \text{constant}$ . We fit an analogous model to the publicly available case data assuming a negative binomial distribution and fitting an additional dispersion parameter.

We obtained crude prevalence estimates as the ratio of swab positive results to numbers tested for all participants and by sub-groups, e.g. age, sex, region, ethnicity, employment type, household size. To correct for population differences due to sampling and differential response, we reweighted the overall prevalence estimates to be representative of the population of England by age, sex, region, ethnicity and deprivation. Because of small numbers of positives, all other prevalence estimates were unweighted.

To investigate the association of test result with covariates, we performed logistic regression on swab positivity as the outcome and: sex, age, region, employment type, ethnicity and household size; as explanatory variables (Table S5). We adjusted for age and sex to obtain odds ratio estimates and 95% confidence intervals for each of the four rounds of data collection. Neither additional adjustments or interaction terms were used because of the small number of positives, especially in round 3 (24th July to 11th August).

To estimate the underlying geographical variation in prevalence over time we fitted a spatio-temporal logistic model (47) in which the numbers of swab-positives are binomially distributed with the log-odds of the underlying prevalence specified as the sum of three terms: a separate intercept for round, to capture the changes in the overall prevalence over time; an

adjustment for the empirical log-odds of response rate, i.e. the number of tested swabs as a proportion of invitation letters sent out; and a latent Gaussian process to capture residual, unexplained variation, with variance  $\sigma^2$  and correlation function  $r(u,v) = \exp(-u/\varphi_1 - v/\varphi_2)$ , where  $u$  is the distance between a pair of LTLA centroids,  $v$  is the time-separation between a pair of rounds and the parameters  $\varphi_1$  and  $\varphi_2$  control the rate at which the correlation decays with increasing distance and time, respectively. Additionally, we included an independent error term with variance  $\tau^2$  to account for within-LTLA over-dispersion. We fitted the model using the R package PrevalMap (48), with Monte Carlo maximum likelihood estimation of all model parameters.

We used rim weighting (49) to adjust prevalence to population estimates of: age by sex; index of multiple deprivation (IMD) deciles; LTLA counts; and ethnic group. The age by sex and LTLA counts were extracted from the Office for National Statistics mid-year population estimates (50), the ethnic group counts from the Labour Force Survey (51), and the IMD deciles profile were derived from the original anonymous population sampling frame from NHS Digital. To allow for the different sources of population estimates, the rim weighting was carried out on the proportions rather than population totals. Age was grouped into seven categories: 18 to 24; 25 to 34; 35 to 44; 45 to 54; 55 to 64; 65 to 74; 75 years or older, giving 14 age-gender categories. The reported ethnicity was grouped into nine categories: white; mixed / multiple ethnic groups; Indian; Pakistani; Bangladeshi; Chinese; any other Asian background; Black African / Caribbean / other; and any other ethnic group or missing.

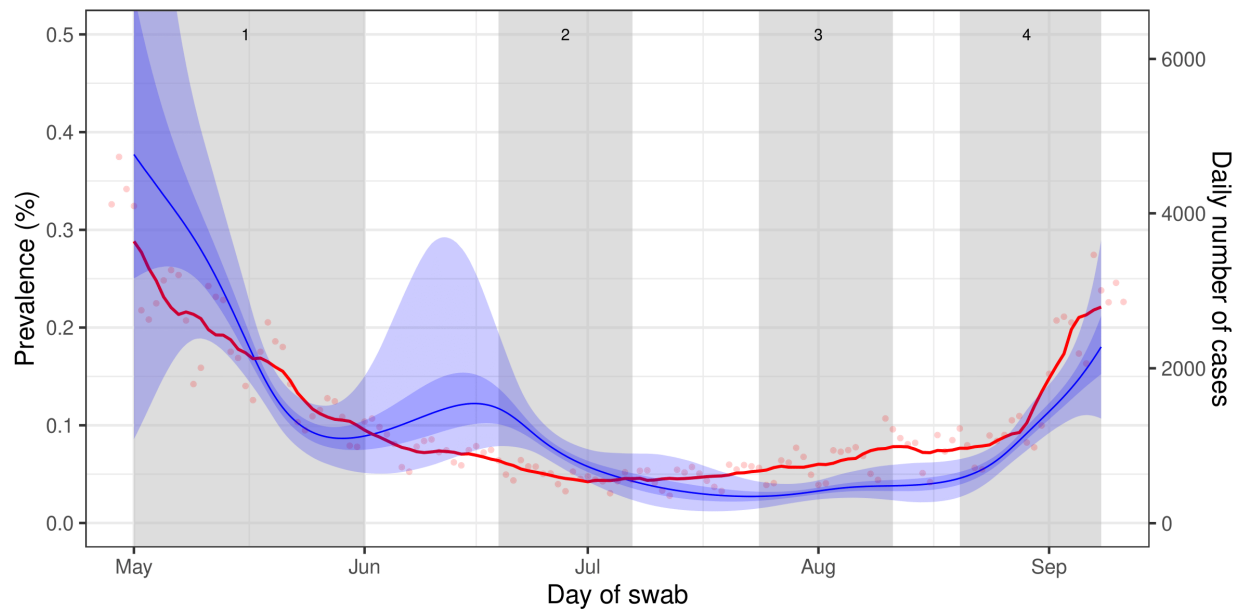
The rim weighting was carried out in two stages. At the first stage, the sample was weighted to LTLA counts and age by sex groups only. In the same stage, the age and sex groups were also adjusted to make sure that the final weighted profile was as close to the population as possible. The second stage of rim weighting adjusted to all four measures, using the first stage weights as the starting weights. The adjustment factor between the first and second stage weights were trimmed at the 1st and 99th percentiles to dampen the extreme weights. The final weights were calculated as the first stage weights multiplied by the trimmed adjustment factor for the second stage. Confidence intervals for weighted prevalence estimates were calculated with the survey package in R (52).

### Ethics

We obtained research ethics approval from the South Central-Berkshire B Research Ethics Committee (IRAS ID: 283787).

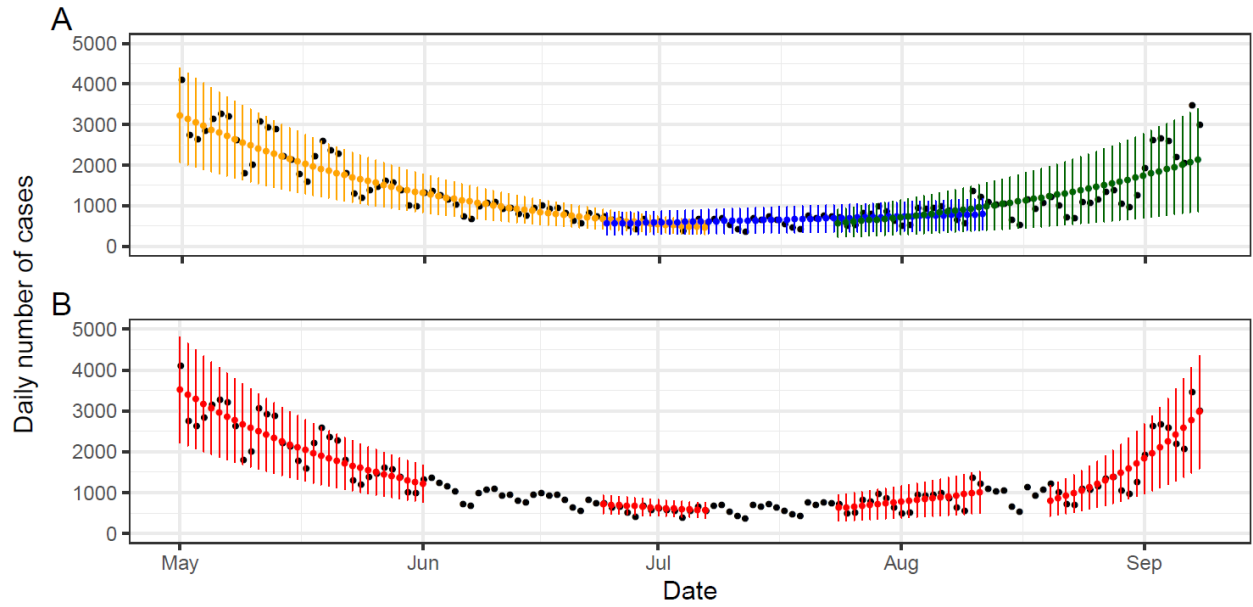
### Public involvement

A Public Advisory Panel is providing input into the design, conduct and dissemination of the REACT research programme.



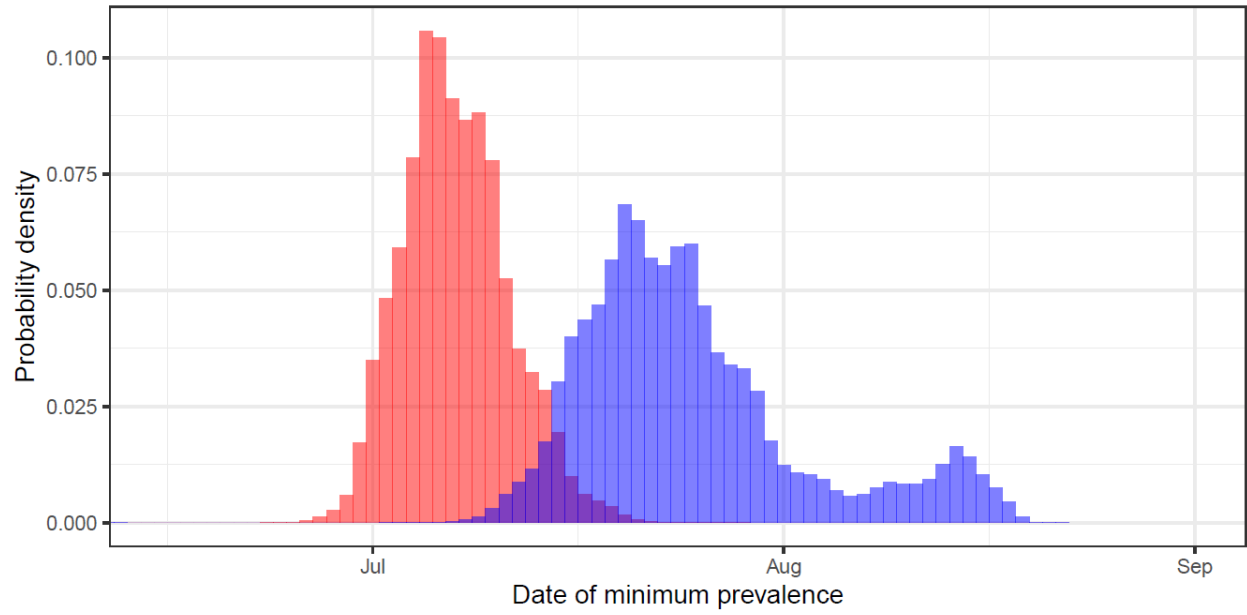
**Fig. S1.** Comparison of REACT-1 and routine case surveillance data.

Prevalence of national swab-positivity and case incidence data for England estimated using a p-spline with data from REACT-1 (Blue, left axis). Central 50% (dark blue) and 95% (light blue) posterior credible intervals. Routine case surveillance data (Red, right axis) also shown with raw data (light red points) and a central 7 day rolling average (current date and 3 days before and after) (red line).



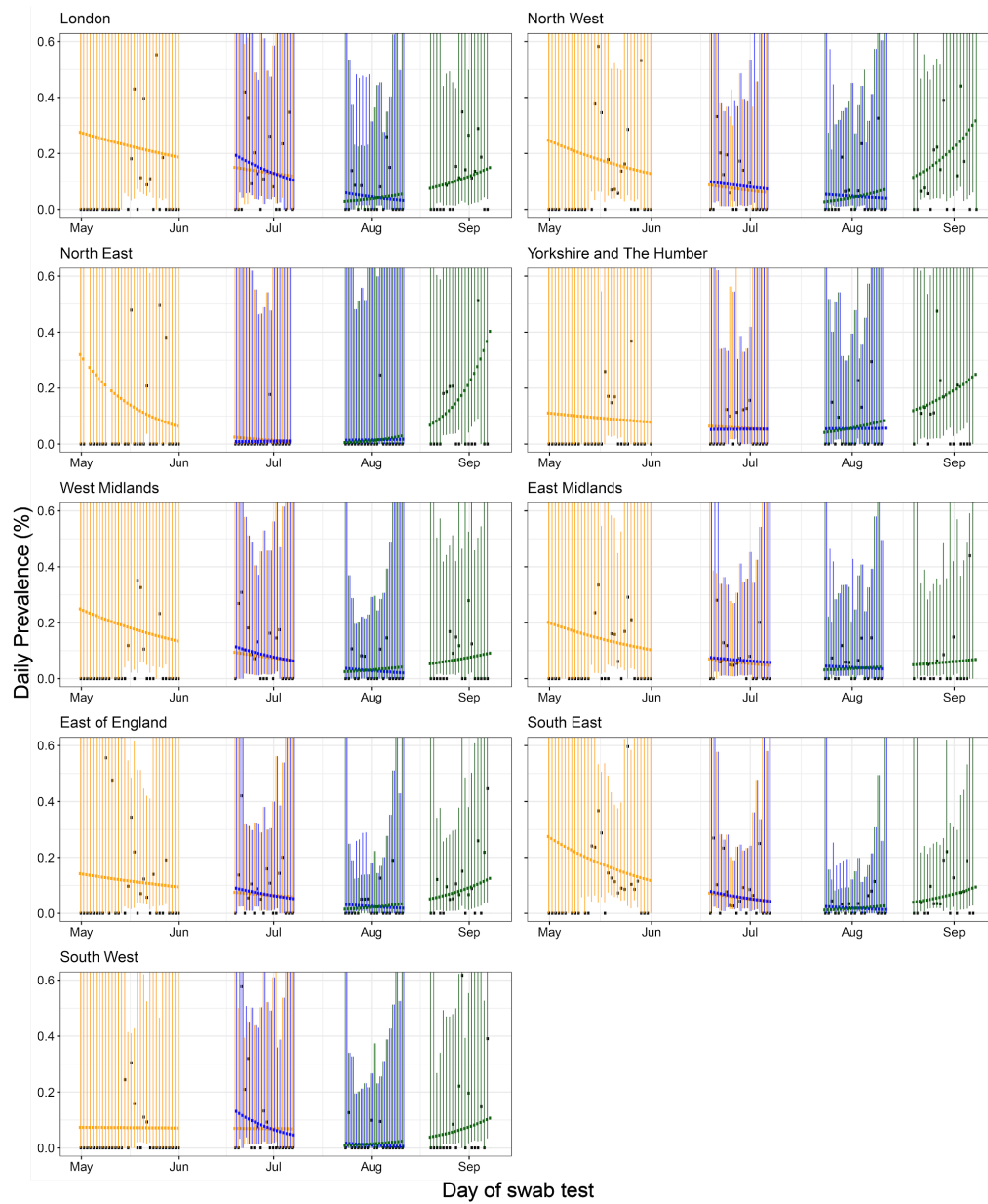
**Fig. S2.** Constant growth rate models fit to routine case surveillance data for sequential and individual rounds.

**A** models fit to symptomatic and key worker test data for the periods of: rounds 1 and 2 (yellow), 2 and 3 (blue) and 3 and 4 (green). **B** models fit to the same period for each individual round (red). Vertical lines show 95% prediction intervals for models. Black points show observations.



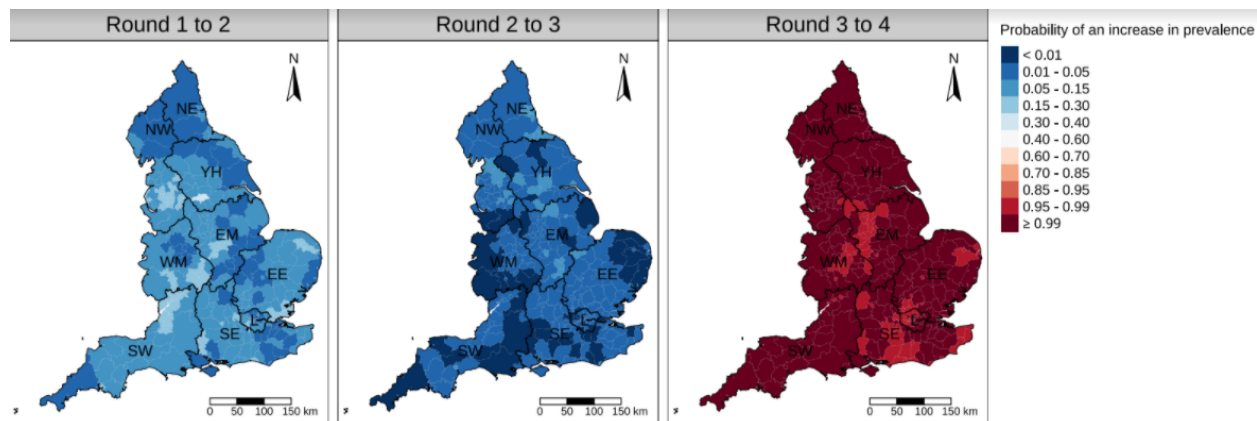
**Fig. S3.** Estimation of the day of epidemic minimum.

Posterior distributions for day of minimum swab-positivity prevalence using REACT-1 data (blue) and minimum symptomatic case incidence using routine surveillance data (red).



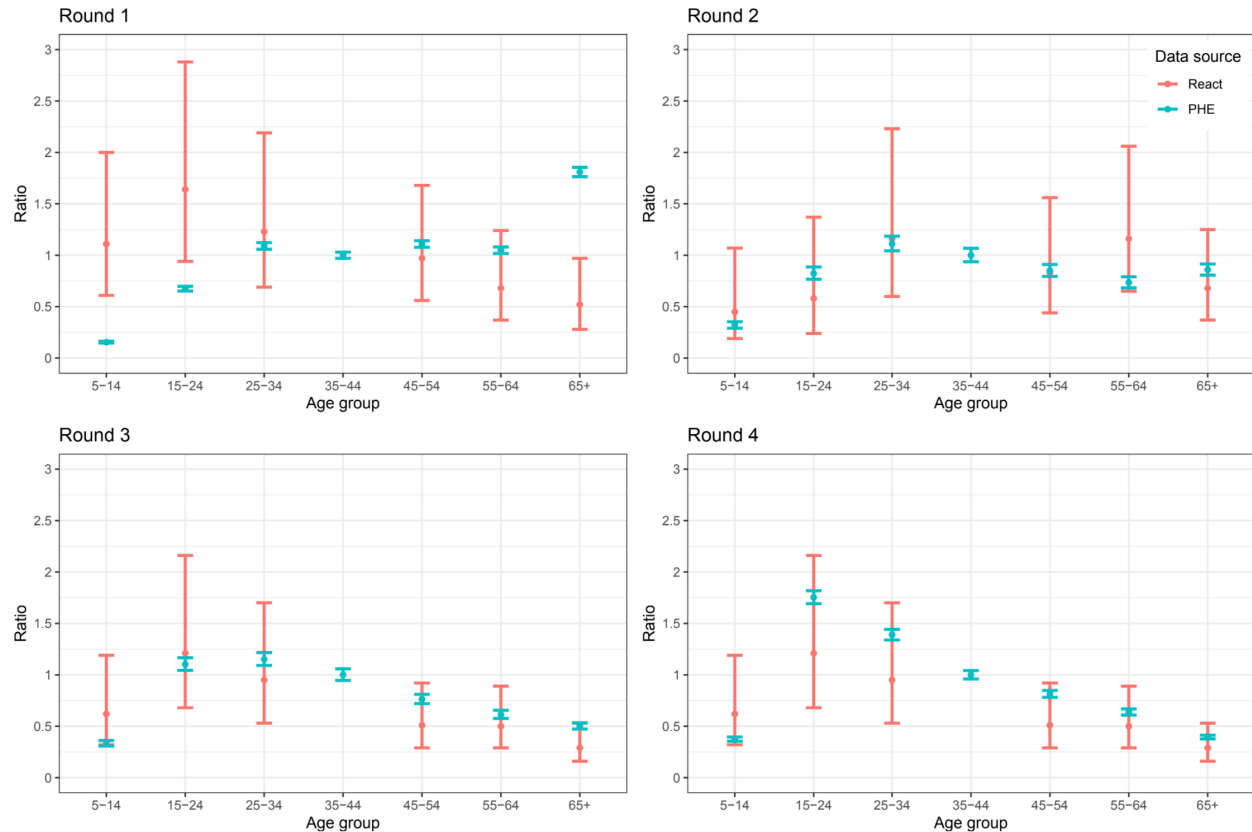
**Fig. S4.** Constant growth rate models fit to sequential rounds of REACT-1 data by region.

Models fit to rounds 1 (yellow), 2 (purple), 3 (blue) and 4 (green). Vertical lines show 95% prediction intervals for models. Black points show observations. See Table S4 for associated R values.



**Fig. S5.** Probability of increasing prevalence by local-tier local authority level.

Regions of England indicated by: L, London; SE, South East; SW, South West; WM, West Midlands; EE, East of England; EM, East Midlands; NW, North West; YH, Yorkshire and The Humber; and NE, North East.



**Fig. S6.** Age-group odds ratios by REACT-1 round for REACT-1 data and routine surveillance data (Public Health England, PHE).

For REACT-1 data, a logistic regression model was used to estimate univariate odds ratios. For routine surveillance data, odds ratios were estimated directly using the number of cases observed during the period of a REACT-1 round. 95% confidence intervals for the routine surveillance odds ratios were calculated by repeated random draws from an assumed underlying binomial distribution.

**Table S1.** Response rate by sex, age group and round.

Sex	Age group	Round 1			Round 2			Round 3			Round 4		
		Invited	Swab tested	Response	Invited	Swab tested	Response	Invited	Swab tested	Response	Invited	Swab tested	Response
Male and Female	5 to 12	39,268	10,660	27.1%	59,106	13,193	22.3%	69,627	11,360	16.3%	69,759	11,119	15.9%
	13 to 17	23,098	7,352	31.8%	35,083	9,510	27.1%	42,059	9,233	22.0%	42,357	8,583	20.3%
	18 to 24	33,809	6,971	20.6%	51,437	7,938	15.4%	60,444	7,472	12.4%	60,238	6,426	10.7%
	25 to 34	58,848	13,426	22.8%	89,835	16,233	18.1%	105,792	15,367	14.5%	104,881	13,951	13.3%
	35 to 44	55,890	16,485	29.5%	85,471	21,048	24.6%	101,194	20,018	19.8%	100,909	19,464	19.3%
	45 to 54	56,951	20,798	36.5%	86,326	26,680	30.9%	101,802	26,780	26.3%	101,912	25,695	25.2%
	55 to 64	51,392	21,166	41.2%	78,080	28,785	36.9%	93,089	30,500	32.8%	93,295	29,004	31.1%
	65+	75,731	24,772	32.7%	114,657	37,401	32.6%	135,955	42,577	31.3%	136,433	40,565	29.7%
	ALL	394,987	121,630	30.8%	599,995	160,788	26.8%	709,962	163,307	23.0%	709,784	154,807	21.8%
Female	5 to 12	19,154	5,232	27.3%	28,814	6,390	22.2%	33,943	5,621	16.6%	34,002	5,444	16.0%
	13 to 17	11,284	3,856	34.2%	17,122	5,019	29.3%	20,544	4,779	23.3%	20,648	4,401	21.3%
	18 to 24	16,987	4,046	23.8%	25,826	4,642	18.0%	30,200	4,396	14.6%	30,116	3,865	12.8%
	25 to 34	29,546	8,037	27.2%	45,121	9,827	21.8%	53,199	9,499	17.9%	52,346	8,591	16.4%
	35 to 44	27,228	9,396	34.5%	41,733	12,300	29.5%	49,279	11,799	23.9%	49,155	11,467	23.3%
	45 to 54	27,910	11,437	41.0%	42,087	14,915	35.4%	49,756	15,023	30.2%	49,734	14,499	29.2%
	55 to 64	25,422	11,189	44.0%	38,809	15,356	39.6%	46,008	16,584	36.0%	46,239	15,827	34.2%
	65+	40721	12923	31.7%	61631	19252	31.2%	73253	22169	30.3%	73353	20980	37.2%
	ALL FEMALE	198,252	66,116	33.3%	301,143	87,701	29.1%	356,182	89,870	25.2%	355,593	85,074	23.9%
Male	5 to 12	20,114	5,428	27.0%	30,292	6,803	22.5%	35,684	5,739	16.1%	35,757	5,675	15.9%
	13 to 17	11,814	3,496	29.6%	17,961	4,491	25.0%	21,515	4,454	20.7%	21,709	4,182	19.3%
	18 to 24	16,822	2,925	17.4%	25,611	3,296	12.9%	30,244	3,076	10.2%	30,122	2,561	8.5%
	25 to 34	29,302	5,389	18.4%	44,714	6,406	14.3%	52,593	5,868	11.2%	52,535	5,360	10.2%
	35 to 44	28,662	7,089	24.7%	43,738	8,748	20.0%	51,915	8,219	15.8%	51,754	7,997	15.5%
	45 to 54	29,041	9,361	32.2%	44,239	11,765	26.6%	52,046	11,757	22.6%	52,178	11,196	21.5%
	55 to 64	25,970	9,977	38.4%	39,271	13,429	34.2%	47,081	13,916	29.6%	47,056	13,177	28.0%
	65+	35010	11849	33.8%	53026	18149	34.2%	62702	20408	32.5%	63080	19585	36.1%
	ALL MALE	196,735	55,514	28.2%	298,852	73,087	24.5%	353,780	73,437	20.8%	354,191	69,733	19.7%

**Table S2.** Estimated growth rates, reproduction numbers and doubling times for SARS-CoV-2 swab-positivity in England, using alternate definitions of swab-positivity.

Data	Round(s)	Number of participants / cases	Growth rate $r$ (1/days)	$P(r>0)$	Reproduction number	Doubling (+) / halving (-) time (days)
REACT, only double-gene positives count as positive (single count as negative)	1	110,994	-0.045 ( -0.093 , 0.005 )	0.05	0.74 ( 0.50 , 1.03 )	-15.4 ( -7.4 , 141.9 )
	2	157,428	-0.112 ( -0.183 , -0.047 )	<0.01	0.43 ( 0.20 , 0.73 )	-6.2 ( -3.8 , -14.8 )
	3	162,619	0.075 ( 0.000 , 0.149 )	0.97	1.54 ( 1.00 , 2.21 )	9.3 ( +Inf , 4.7 )
	4	153,964	0.093 ( 0.049 , 0.140 )	>0.99	1.69 ( 1.34 , 2.12 )	7.4 ( 14.2 , 4.9 )
	1 and 2	268,422	-0.012 ( -0.021 , -0.003 )	<0.01	0.92 ( 0.87 , 0.98 )	-55.5 ( -32.4 , -199.8 )
	2 and 3	320,047	-0.020 ( -0.031 , -0.008 )	<0.01	0.88 ( 0.81 , 0.95 )	-35.3 ( -22.1 , -84.6 )
	3 and 4	316,583	0.041 ( 0.027 , 0.055 )	>0.99	1.28 ( 1.18 , 1.38 )	17.1 ( 25.5 , 12.7 )
REACT, Only asymptomatic positives count as positives	1	110,968	-0.095 ( -0.134 , -0.053 )	<0.01	0.50 ( 0.35 , 0.69 )	-7.3 ( -5.2 , -13.0 )
	2	157,416	-0.109 ( -0.169 , -0.053 )	<0.01	0.44 ( 0.24 , 0.70 )	-6.4 ( -4.1 , -13.2 )
	3	162,606	0.069 ( -0.011 , 0.153 )	0.95	1.49 ( 0.93 , 2.25 )	10.1 ( -61.4 , 4.5 )
	4	153,943	0.070 ( 0.024 , 0.118 )	>0.99	1.51 ( 1.16 , 1.91 )	9.8 ( 29.2 , 5.9 )
	1 and 2	268,384	-0.013 ( -0.021 , -0.005 )	<0.01	0.92 ( 0.87 , 0.97 )	-54.0 ( -33.7 , -135.9 )
	2 and 3	320,022	-0.034 ( -0.047 , -0.023 )	<0.01	0.80 ( 0.73 , 0.86 )	-20.2 ( -14.9 , -30.2 )
	3 and 4	316,549	0.040 ( 0.026 , 0.056 )	>0.99	1.27 ( 1.17 , 1.39 )	17.2 ( 26.6 , 12.5 )

\* See Table 1 for start and end dates of rounds

**Table S3.** Estimated growth rates, reproduction numbers and doubling times for SARS-CoV-2 swab-positivity in regions of England.

Region	Rounds	Number of participants / cases	Growth rate $r$ (1/days)	$P(r>0)$	Reproduction number	Doubling (+) / halving (-) time (days)
South East	1 and 2	59,471	-0.027 ( -0.041 , -0.014 )	<0.01	0.84 ( 0.76 , 0.92 )	-25.5 ( -16.7 , -50.9 )
	2 and 3	70,437	-0.033 ( -0.060 , -0.010 )	<0.01	0.80 ( 0.66 , 0.94 )	-20.9 ( -11.6 , -68.6 )
	3 and 4	70,855	0.045 ( 0.015 , 0.076 )	>0.99	1.31 ( 1.10 , 1.55 )	15.5 ( 45.2 , 9.1 )
North East	1 and 2	9,913	-0.052 ( -0.119 , -0.004 )	0.02	0.70 ( 0.40 , 0.98 )	-13.3 ( -5.8 , -179.4 )
	2 and 3	11,586	0.0123 ( -0.084 , 0.1167 )	0.61	1.08 ( 0.54 , 1.90 )	56.3 ( -8.224 , 5.9355 )
	3 and 4	11,493	0.0905 ( 0.0295 , 0.1756 )	>0.99	1.67 ( 1.20 , 2.48 )	7.7 ( 23.256 , 3.9457 )
North West	1 and 2	32,745	-0.0211 ( -0.038 , -0.004 )	0.01	0.87 ( 0.77 , 0.97 )	-32.8 ( -17.89 , -157.6 )
	2 and 3	37,946	-0.017 ( -0.041 , 0.005 )	0.07	0.89 ( 0.76 , 1.03 )	-40.4 ( -16.8 , 129.5 )
	3 and 4	36,738	0.052 ( 0.028 , 0.079 )	>0.99	1.37 ( 1.19 , 1.58 )	13.2 ( 24.6 , 8.7 )
Yorkshire	1 and 2	17,381	-0.011 ( -0.041 , 0.019 )	0.23	0.93 ( 0.76 , 1.13 )	-61.9 ( -16.8 , 35.8 )
	2 and 3	21,089	0.001 ( -0.032 , 0.035 )	0.53	1.01 ( 0.81 , 1.24 )	547.9 ( -21.9 , 19.8 )
	3 and 4	20,999	0.039 ( 0.008 , 0.072 )	0.99	1.26 ( 1.05 , 1.52 )	18.0 ( 84.0 , 9.6 )
East Midlands	1 and 2	34,757	-0.021 ( -0.041 , -0.003 )	0.01	0.87 ( 0.76 , 0.98 )	-32.4 ( -16.9 , -227.3 )
	2 and 3	41,418	-0.015 ( -0.039 , 0.008 )	0.11	0.91 ( 0.77 , 1.05 )	-47.5 ( -17.7 , 82.5 )
	3 and 4	40,297	0.017 ( -0.012 , 0.049 )	0.86	1.11 ( 0.92 , 1.34 )	40.9 ( -55.6 , 14.0 )
West Midlands	1 and 2	25,135	-0.020 ( -0.039 , -0.001 )	0.02	0.88 ( 0.77 , 0.99 )	-35.0 ( -17.7 , -679.6 )
	2 and 3	29,965	-0.032 ( -0.066 , -0.004 )	0.01	0.81 ( 0.63 , 0.97 )	-21.5 ( -10.6 , -170.9 )
	3 and 4	29,608	0.029 ( -0.007 , 0.068 )	0.94	1.19 ( 0.96 , 1.49 )	24.3 ( -98.4 , 10.2 )
East of England	1 and 2	39,008	-0.013 ( -0.030 , 0.005 )	0.08	0.92 ( 0.82 , 1.03 )	-53.6 ( -22.8 , 135.5 )
	2 and 3	46,419	-0.030 ( -0.057 , -0.005 )	0.01	0.82 ( 0.67 , 0.97 )	-23.2 ( -12.1 , -138.0 )
	3 and 4	46,427	0.046 ( 0.015 , 0.083 )	>0.99	1.32 ( 1.10 , 1.60 )	15.0 ( 44.8 , 8.4 )
London	1 and 2	25,171	-0.012 ( -0.028 , 0.004 )	0.06	0.92 ( 0.83 , 1.02 )	-55.7 ( -24.4 , 186.6 )
	2 and 3	30,550	-0.034 ( -0.060 , -0.011 )	<0.01	0.80 ( 0.66 , 0.93 )	-20.5 ( -11.6 , -60.4 )
	3 and 4	29,953	0.035 ( 0.003 , 0.069 )	0.98	1.23 ( 1.02 , 1.49 )	20.0 ( 242.4 , 10.1 )
South West	1 and 2	24,841	-0.001 ( -0.025 , 0.023 )	0.46	0.99 ( 0.85 , 1.16 )	-614.2 ( -27.3 , 29.6 )
	2 and 3	30,637	-0.058 ( -0.107 , -0.021 )	<0.01	0.67 ( 0.45 , 0.87 )	-12.0 ( -6.5 , -33.3 )
	3 and 4	30,213	0.057 ( 0.015 , 0.110 )	>0.99	1.40 ( 1.10 , 1.84 )	12.1 ( 44.8 , 6.3 )

**Table S4.** Unweighted prevalence of infection for rounds 1 to 4 by variable and category.

Variable	Category	Round 1			Round 2		
		Positive	Total	Prevalence	Positive	Total	Prevalence
Gender	Male	73	55,064	0.13% ( 0.11% , 0.17% )	59	72,371	0.08% ( 0.06% , 0.11% )
	Female	86	65,556	0.13% ( 0.11% , 0.16% )	64	86,828	0.07% ( 0.06% , 0.09% )
Age	05-12	17	10,573	0.16% ( 0.10% , 0.26% )	6	13,077	0.05% ( 0.02% , 0.10% )
	13-17	11	7,293	0.15% ( 0.08% , 0.27% )	4	9,425	0.04% ( 0.02% , 0.11% )
	18-24	19	6,916	0.27% ( 0.18% , 0.43% )	4	7,873	0.05% ( 0.02% , 0.13% )
	25-34	23	13,317	0.17% ( 0.12% , 0.26% )	17	16,073	0.11% ( 0.07% , 0.17% )
	35-44	23	16,372	0.14% ( 0.09% , 0.21% )	19	20,848	0.09% ( 0.06% , 0.14% )
	45-54	28	20,617	0.14% ( 0.09% , 0.20% )	20	26,397	0.08% ( 0.05% , 0.12% )
	55-64	20	20,980	0.10% ( 0.06% , 0.15% )	30	28,463	0.11% ( 0.07% , 0.15% )
	65+	18	24,552	0.07% ( 0.05% , 0.12% )	23	37,043	0.06% ( 0.04% , 0.09% )
Region	South East	41	27,145	0.15% ( 0.11% , 0.20% )	21	34,748	0.06% ( 0.04% , 0.09% )
	North East	5	4,511	0.11% ( 0.05% , 0.26% )	1	5,920	0.02% ( 0.00% , 0.10% )
	North West	24	15,645	0.15% ( 0.10% , 0.23% )	16	18,615	0.09% ( 0.05% , 0.14% )
	Yorkshire and The Humber	7	7,775	0.09% ( 0.04% , 0.19% )	6	10,312	0.06% ( 0.03% , 0.13% )
	East Midlands	18	15,429	0.12% ( 0.07% , 0.18% )	14	20,733	0.07% ( 0.04% , 0.11% )
	West Midlands	19	11,337	0.17% ( 0.11% , 0.26% )	13	14,927	0.09% ( 0.05% , 0.15% )
	East of England	18	17,598	0.10% ( 0.06% , 0.16% )	17	23,101	0.07% ( 0.05% , 0.12% )
	London	21	10,488	0.20% ( 0.13% , 0.31% )	23	15,750	0.15% ( 0.10% , 0.22% )
	South West	6	10,692	0.06% ( 0.03% , 0.12% )	12	15,093	0.08% ( 0.05% , 0.14% )
Employment type	Health care or care home worker	30	32,588	0.09% ( 0.06% , 0.13% )	53	65,326	0.08% ( 0.06% , 0.11% )
	Other essential/key worker	21	4,225	0.50% ( 0.33% , 0.76% )	7	7,988	0.09% ( 0.04% , 0.18% )
	Other worker	28	16,364	0.17% ( 0.12% , 0.25% )	26	26,575	0.10% ( 0.07% , 0.14% )
	Not full-time, part-time, or self-employed	42	36,518	0.12% ( 0.09% , 0.16% )	36	54,677	0.07% ( 0.05% , 0.09% )
Ethnic group	White	140	111,502	0.13% ( 0.11% , 0.15% )	108	145,080	0.07% ( 0.06% , 0.09% )
	Asian	11	4,578	0.24% ( 0.13% , 0.43% )	7	7,103	0.10% ( 0.05% , 0.20% )
	Black	2	1,188	0.17% ( 0.05% , 0.61% )	3	1,977	0.15% ( 0.05% , 0.45% )
	Mixed	4	2,281	0.18% ( 0.07% , 0.45% )	2	2,896	0.07% ( 0.02% , 0.25% )
	Other	2	937	0.21% ( 0.06% , 0.77% )	2	1,377	0.15% ( 0.04% , 0.53% )
Household size	1	10	15,384	0.07% ( 0.04% , 0.12% )	21	22,643	0.09% ( 0.06% , 0.14% )
	2	46	38,671	0.12% ( 0.09% , 0.16% )	44	53,062	0.08% ( 0.06% , 0.11% )
	3	37	23,038	0.16% ( 0.12% , 0.22% )	30	29,601	0.10% ( 0.07% , 0.14% )
	4	40	27,450	0.15% ( 0.11% , 0.20% )	22	35,140	0.06% ( 0.04% , 0.09% )
	5	18	10,257	0.18% ( 0.11% , 0.28% )	2	13,046	0.02% ( 0.00% , 0.06% )
	6	4	3,135	0.13% ( 0.05% , 0.33% )	1	3,835	0.03% ( 0.00% , 0.15% )
	7+	2	1,382	0.14% ( 0.04% , 0.53% )	3	1,872	0.16% ( 0.05% , 0.47% )
COVID case contact	No	96	91,047	0.11% ( 0.09% , 0.13% )	101	129,887	0.08% ( 0.06% , 0.09% )
	Yes, contact with a confirmed/tested COVID-19 case	25	1,000	2.50% ( 1.70% , 3.66% )	9	533	1.69% ( 0.89% , 3.18% )
	Yes, contact with a suspected COVID-19 case	5	894	0.56% ( 0.24% , 1.30% )	1	625	0.16% ( 0.03% , 0.90% )
Hospital contact	No	88	82,875	0.11% ( 0.09% , 0.13% )	10	7,522	0.13% ( 0.07% , 0.24% )
	Yes, I have	20	4,605	0.43% ( 0.28% , 0.67% )	4	8,131	0.05% ( 0.02% , 0.13% )
	Yes, my child has	NA	NA	NA ( NA , NA )	NA	NA	NA ( NA , NA )
	Yes, someone in my household has	16	4,983	0.32% ( 0.20% , 0.52% )	1	840	0.12% ( 0.02% , 0.67% )
	Don't Know	1	360	0.28% ( 0.05% , 1.56% )	96	114,411	0.08% ( 0.07% , 0.10% )
Symptom status	Classic COVID symptoms	20	5,814	0.34% ( 0.22% , 0.53% )	11	2,898	0.38% ( 0.21% , 0.68% )
	Other symptoms	19	14,633	0.13% ( 0.08% , 0.20% )	10	10,108	0.10% ( 0.05% , 0.18% )
	No symptoms	87	72,678	0.12% ( 0.10% , 0.15% )	90	118,740	0.08% ( 0.06% , 0.09% )

**Table S4 (cont).** Unweighted prevalence of infection for rounds 1 to 4 by variable and category.

Variable	Category	Round 3			Round 4		
		Positive	Total	Prevalence	Positive	Total	Prevalence
Gender	Male	24	73,211	0.03% ( 0.02% , 0.05% )	61	69,524	0.09% ( 0.07% , 0.11% )
	Female	30	89,607	0.03% ( 0.02% , 0.05% )	76	84,797	0.09% ( 0.07% , 0.11% )
Age	05-12	2	11,329	0.02% ( 0.00% , 0.06% )	11	11,088	0.10% ( 0.06% , 0.18% )
	13-17	6	9,209	0.07% ( 0.03% , 0.14% )	6	8,559	0.07% ( 0.03% , 0.15% )
	18-24	6	7,452	0.08% ( 0.04% , 0.18% )	16	6,410	0.25% ( 0.15% , 0.41% )
	25-34	8	15,321	0.05% ( 0.03% , 0.10% )	19	13,900	0.14% ( 0.09% , 0.21% )
	35-44	8	19,956	0.04% ( 0.02% , 0.08% )	28	19,404	0.14% ( 0.10% , 0.21% )
	45-54	3	26,692	0.01% ( 0.00% , 0.03% )	19	25,603	0.07% ( 0.05% , 0.12% )
	55-64	6	30,402	0.02% ( 0.01% , 0.04% )	21	28,907	0.07% ( 0.05% , 0.11% )
	65+	15	42,461	0.04% ( 0.02% , 0.06% )	17	40,454	0.04% ( 0.03% , 0.07% )
Region	South East	7	36,118	0.02% ( 0.01% , 0.04% )	20	34,845	0.06% ( 0.04% , 0.09% )
	North East	1	5,787	0.02% ( 0.00% , 0.10% )	9	5,714	0.16% ( 0.08% , 0.30% )
	North West	10	19,577	0.05% ( 0.03% , 0.09% )	29	17,212	0.17% ( 0.12% , 0.24% )
	Yorkshire and The Humber	6	10,920	0.05% ( 0.03% , 0.12% )	17	10,113	0.17% ( 0.11% , 0.27% )
	East Midlands	9	20,882	0.04% ( 0.02% , 0.08% )	10	19,470	0.05% ( 0.03% , 0.09% )
	West Midlands	5	15,193	0.03% ( 0.01% , 0.08% )	10	14,460	0.07% ( 0.04% , 0.13% )
	East of England	6	23,633	0.03% ( 0.01% , 0.06% )	17	22,849	0.07% ( 0.05% , 0.12% )
	London	7	15,062	0.05% ( 0.02% , 0.10% )	15	14,992	0.10% ( 0.06% , 0.17% )
	South West	3	15,650	0.02% ( 0.01% , 0.06% )	10	14,670	0.07% ( 0.04% , 0.13% )
Employment type	Health care or care home worker	18	67,534	0.03% ( 0.02% , 0.04% )	64	63,152	0.10% ( 0.08% , 0.13% )
	Other essential/key worker	4	8,289	0.05% ( 0.02% , 0.12% )	13	7,900	0.16% ( 0.10% , 0.28% )
	Other worker	10	26,979	0.04% ( 0.02% , 0.07% )	28	25,363	0.11% ( 0.08% , 0.16% )
	Not full-time, part-time, or self-employed	19	56,250	0.03% ( 0.02% , 0.05% )	30	54,420	0.06% ( 0.04% , 0.08% )
Ethnic group	White	44	147,242	0.03% ( 0.02% , 0.04% )	106	139,655	0.08% ( 0.06% , 0.09% )
	Asian	5	7,124	0.07% ( 0.03% , 0.16% )	13	6,632	0.20% ( 0.11% , 0.34% )
	Black	2	2,041	0.10% ( 0.03% , 0.36% )	4	2,014	0.20% ( 0.08% , 0.51% )
	Mixed	1	2,796	0.04% ( 0.01% , 0.20% )	4	2,546	0.16% ( 0.06% , 0.40% )
	Other	1	1,368	0.07% ( 0.01% , 0.41% )	3	1,256	0.24% ( 0.08% , 0.70% )
Household size	1	5	24,134	0.02% ( 0.01% , 0.05% )	15	22,195	0.07% ( 0.04% , 0.11% )
	2	15	58,124	0.03% ( 0.02% , 0.04% )	35	55,814	0.06% ( 0.05% , 0.09% )
	3	10	29,502	0.03% ( 0.02% , 0.06% )	27	27,953	0.10% ( 0.07% , 0.14% )
	4	17	33,756	0.05% ( 0.03% , 0.08% )	35	32,382	0.11% ( 0.08% , 0.15% )
	5	1	12,084	0.01% ( 0.00% , 0.05% )	18	11,254	0.16% ( 0.10% , 0.25% )
	6	5	3,508	0.14% ( 0.06% , 0.33% )	3	3,234	0.09% ( 0.03% , 0.27% )
	7+	1	1,714	0.06% ( 0.01% , 0.33% )	4	1,493	0.27% ( 0.10% , 0.69% )
COVID case contact	No	36	133,966	0.03% ( 0.02% , 0.04% )	103	127,757	0.08% ( 0.07% , 0.10% )
	Yes, contact with a confirmed/tested COVID-19 case	3	355	0.85% ( 0.29% , 2.45% )	9	329	2.74% ( 1.45% , 5.12% )
	Yes, contact with a suspected COVID-19 case	1	451	0.22% ( 0.04% , 1.25% )	3	393	0.76% ( 0.26% , 2.22% )
Hospital contact	No	31	114,980	0.03% ( 0.02% , 0.04% )	95	109,264	0.09% ( 0.07% , 0.11% )
	Yes, I have	1	9,924	0.01% ( 0.00% , 0.06% )	12	9,775	0.12% ( 0.07% , 0.21% )
	Yes, my child has	0	113	0.00% ( 0.00% , 2.34% )	0	1,001	0.00% ( 0.00% , 0.27% )
	Yes, someone in my household has	8	8,876	0.09% ( 0.05% , 0.18% )	7	7,574	0.09% ( 0.04% , 0.19% )
	Don't Know	0	743	0.00% ( 0.00% , 0.36% )	0	735	0.00% ( 0.00% , 0.37% )
Symptom status	Classic COVID symptoms	8	2,806	0.29% ( 0.14% , 0.56% )	26	3,832	0.68% ( 0.46% , 0.99% )
	Other symptoms	3	10,819	0.03% ( 0.01% , 0.08% )	14	13,656	0.10% ( 0.06% , 0.17% )
	No symptoms	30	121,230	0.02% ( 0.02% , 0.04% )	76	111,106	0.07% ( 0.05% , 0.09% )

**Table S4 (cont).** Unweighted prevalence of infection for rounds 1 to 4 by variable and category.

Variable	Category	Total rounds 1 to 4		
		Positive	Total	Prevalence
Gender	Male	217	270,170	0.08% ( 0.07% , 0.09% )
	Female	256	326,788	0.08% ( 0.07% , 0.09% )
Age	05-12	36	46,067	0.08% ( 0.06% , 0.11% )
	13-17	27	34,486	0.08% ( 0.05% , 0.11% )
	18-24	45	28,651	0.16% ( 0.12% , 0.21% )
	25-34	67	58,611	0.11% ( 0.09% , 0.15% )
	35-44	78	76,580	0.10% ( 0.08% , 0.13% )
	45-54	70	99,309	0.07% ( 0.06% , 0.09% )
	55-64	77	108,752	0.07% ( 0.06% , 0.09% )
	65+	73	144,510	0.05% ( 0.04% , 0.06% )
Region	South East	89	132,856	0.07% ( 0.05% , 0.08% )
	North East	16	21,932	0.07% ( 0.04% , 0.12% )
	North West	79	71,049	0.11% ( 0.09% , 0.14% )
	Yorkshire and The Humber	36	39,120	0.09% ( 0.07% , 0.13% )
	East Midlands	51	76,514	0.07% ( 0.05% , 0.09% )
	West Midlands	47	55,917	0.08% ( 0.06% , 0.11% )
	East of England	58	87,181	0.07% ( 0.05% , 0.09% )
	London	66	56,292	0.12% ( 0.09% , 0.15% )
	South West	31	56,105	0.06% ( 0.04% , 0.08% )
Employment type	Health care or care home	165	228,600	0.07% ( 0.06% , 0.08% )
	Other essential/key	45	28,402	0.16% ( 0.12% , 0.21% )
	Other worker	92	95,281	0.10% ( 0.08% , 0.12% )
	Not full-time, part-time, or	127	201,865	0.06% ( 0.05% , 0.07% )
Ethnic group	White	398	543,479	0.07% ( 0.07% , 0.08% )
	Asian	36	25,437	0.14% ( 0.10% , 0.20% )
	Black	11	7,220	0.15% ( 0.09% , 0.27% )
	Mixed	11	10,519	0.10% ( 0.06% , 0.19% )
	Other	8	4,938	0.16% ( 0.08% , 0.32% )
Household size	1	51	84,356	0.06% ( 0.05% , 0.08% )
	2	140	205,671	0.07% ( 0.06% , 0.08% )
	3	104	110,094	0.09% ( 0.08% , 0.11% )
	4	114	128,728	0.09% ( 0.07% , 0.11% )
	5	39	46,641	0.08% ( 0.06% , 0.11% )
	6	13	13,712	0.09% ( 0.06% , 0.16% )
	7+	10	6,461	0.15% ( 0.08% , 0.28% )
COVID case contact	No	336	482,657	0.07% ( 0.06% , 0.08% )
	Yes, contact with a	46	2,217	2.07% ( 1.56% , 2.76% )
	Yes, contact with a	10	2,363	0.42% ( 0.23% , 0.78% )
Hospital contact	No	224	314,641	0.07% ( 0.06% , 0.08% )
	Yes, I have	37	32,435	0.11% ( 0.08% , 0.16% )
	Yes, my child has	0	1,114	0.00% ( 0.00% , 0.24% )
	Yes, someone in my	32	22,273	0.14% ( 0.10% , 0.20% )
	Don't Know	97	116,249	0.08% ( 0.07% , 0.10% )
Symptom status	Classic COVID symptoms	65	15,350	0.42% ( 0.33% , 0.54% )
	Other symptoms	46	49,216	0.09% ( 0.07% , 0.12% )
	No symptoms	283	423,754	0.07% ( 0.06% , 0.08% )

**Table S5.** Parameters of the geospatial model.

Parameter	Description	Estimate (95% Confidence Interval)	
Intercept	Offset	-7.344	(-7.480, -7.208)
Round 2	Round-specific log odds	-0.676	(-0.833, -0.518)
Round 3	Round-specific log odds	-1.572	(-1.743, -1.401)
Round 4	Round-specific log odds	-0.656	(-0.832, -0.481)
Response rate	Contribution of empirical logit of the number of tested swabs as a proportion of invitation letters sent out	-0.677	(-0.769, -0.585)
$\phi_1$	Spatial correlation range	22.606	(16.099, 31.742)
$\phi_2$	Temporal correlation range	26.095	(16.928, 40.225)
$\sigma^2$	Variance of Gaussian process	0.148	(0.116, 0.190)
$\tau^2$	Overdispersion of error term	0.139	(0.072, 0.268)

**Table S6.** Logistic regression models adjusted for age and gender for REACT-1 rounds 1, 2, 3 and 4.

Variable	Category	Round 1	Round 2	Round 3	Round 4
Gender	Male	ref	ref	ref	ref
	Female	0.98 [0.71,1.33]	0.90 [0.63,1.29]	1.02 [0.60,1.75]	1.00 [0.71,1.40]
Age group (yr)	5 - 35'	1.66 [1.15,2.38]	0.79 [0.50,1.24]	2.60 [1.24,5.46]	1.29 [0.88,1.89]
	36 - 56	ref	ref	ref	ref
	57 +	0.73 [0.47,1.13]	0.96 [0.64,1.45]	1.61 [0.76,3.42]	0.49 [0.32,0.77]
Region	South East	ref	ref	ref	ref
	North East	0.74 [0.29,1.87]	0.28 [0.04,2.07]	0.90 [0.11,7.28]	2.78 [1.26,6.11]
	North West	1.01 [0.61,1.68]	1.42 [0.74,2.73]	2.62 [1.00,6.88]	2.98 [1.69,5.27]
	Yorkshire and The Humber	0.60 [0.27,1.34]	0.96 [0.39,2.38]	2.83 [0.95,8.43]	3.00 [1.57,5.74]
	East Midlands	0.77 [0.44,1.34]	1.12 [0.57,2.20]	2.23 [0.83,5.98]	0.91 [0.42,1.94]
	West Midlands	1.10 [0.64,1.90]	1.44 [0.72,2.88]	1.69 [0.54,5.34]	1.21 [0.57,2.59]
	East of England	0.67 [0.39,1.17]	1.22 [0.64,2.31]	1.31 [0.44,3.88]	1.30 [0.68,2.48]
	London	1.24 [0.73,2.11]	2.47 [1.37,4.48]	2.30 [0.80,6.57]	1.58 [0.81,3.10]
	South West	0.38 [0.16,0.89]	1.31 [0.64,2.67]	0.99 [0.26,3.83]	1.23 [0.58,2.64]
Employment type	Health care or care home worker	5.49 [3.11,9.69]	1.13 [0.51,2.50]	1.85 [0.62,5.51]	1.53 [0.84,2.80]
	Other key worker	1.83 [1.09,3.06]	1.23 [0.76,1.97]	1.44 [0.66,3.14]	1.02 [0.65,1.59]
	Other worker	ref	ref	ref	ref
	Not full time, part time or self employed	1.40 [0.86,2.30]	0.79 [0.50,1.25]	1.16 [0.59,2.28]	0.66 [0.42,1.04]
Ethnicity	White	ref	ref	ref	ref
	Asian	1.71 [0.92,3.17]	1.37 [0.64,2.97]	2.26 [0.88,5.76]	2.20 [1.23,3.93]
	Black	1.26 [0.31,5.09]	2.09 [0.66,6.59]	3.20 [0.77,13.29]	2.28 [0.84,6.22]
	Mixed	1.10 [0.40,2.99]	1.02 [0.25,4.19]	1.01 [0.14,7.46]	1.63 [0.60,4.47]
	Other	1.63 [0.40,6.58]	1.99 [0.49,8.08]	2.44 [0.34,17.80]	2.82 [0.89,8.90]
Household size	1 - 2'	ref	ref	ref	ref
	3 - 5'	1.14 [0.78,1.66]	0.80 [0.53,1.22]	1.71 [0.86,3.42]	1.21 [0.80,1.82]
	6 +	0.88 [0.40,1.90]	0.83 [0.29,2.36]	4.85 [1.76,13.42]	1.52 [0.67,3.47]

**Table S7.** Reproduction numbers estimated for different generation time assumptions.

Round(s)	Growth rate $r$	Reproduction Number						
		Bi et al	Wang and Teunis et al	Lopez Bernal et al	Du et al	Knight and Mishra et al	Zhang et al	
1	-0.077 ( -0.107 , -0.046 )	0.58 ( 0.45 , 0.70 )	0.67 ( 0.57 , 0.80 )	0.68 ( 0.57 , 0.80 )	0.69 ( 0.58 , 0.81 )	0.71 ( 0.61 , 0.82 )	0.66 ( 0.55 , 0.78 )	
2	-0.089 ( -0.13 , -0.032 )	0.52 ( 0.36 , 0.80 )	0.63 ( 0.50 , 0.85 )	0.63 ( 0.48 , 0.86 )	0.64 ( 0.49 , 0.87 )	0.67 ( 0.54 , 0.88 )	0.61 ( 0.48 , 0.85 )	
3	0.049 ( -0.012 , 0.109 )	1.34 ( 0.93 , 1.80 )	1.25 ( 0.94 , 1.62 )	1.23 ( 0.95 , 1.53 )	1.18 ( 0.95 , 1.35 )	1.20 ( 0.95 , 1.48 )	1.27 ( 0.94 , 1.68 )	
4	0.086 ( 0.05 , 0.122 )	1.63 ( 1.35 , 2.00 )	1.47 ( 1.26 , 1.71 )	1.41 ( 1.23 , 1.59 )	1.29 ( 1.19 , 1.37 )	1.37 ( 1.21 , 1.54 )	1.52 ( 1.28 , 1.78 )	
1 and 2	-0.018 ( -0.025 , -0.012 )	0.89 ( 0.85 , 0.90 )	0.92 ( 0.88 , 0.94 )	0.92 ( 0.89 , 0.95 )	0.93 ( 0.90 , 0.95 )	0.93 ( 0.90 , 0.95 )	0.91 ( 0.88 , 0.94 )	
2 and 3	-0.025 ( -0.034 , -0.017 )	0.85 ( 0.80 , 0.90 )	0.88 ( 0.85 , 0.92 )	0.89 ( 0.85 , 0.93 )	0.90 ( 0.86 , 0.93 )	0.90 ( 0.87 , 0.93 )	0.88 ( 0.84 , 0.92 )	
3 and 4	0.041 ( 0.03 , 0.051 )	1.28 ( 1.20 , 1.40 )	1.21 ( 1.15 , 1.27 )	1.19 ( 1.14 , 1.24 )	1.15 ( 1.11 , 1.19 )	1.17 ( 1.12 , 1.21 )	1.23 ( 1.16 , 1.29 )	

Bi et al [https://www.thelancet.com/journals/laninf/article/PIIS1473-3099\(20\)30287-5/fulltext](https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30287-5/fulltext)

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(Gamma distributed estimate from all households)

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**Data S1. (separate file)**

We provide an `xlsx` file with the data for all tables. Also, Ref (45) links to an R package that contains key aggregate data as `csvs` in the `inst/extdata` directory.

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