

## Appendices

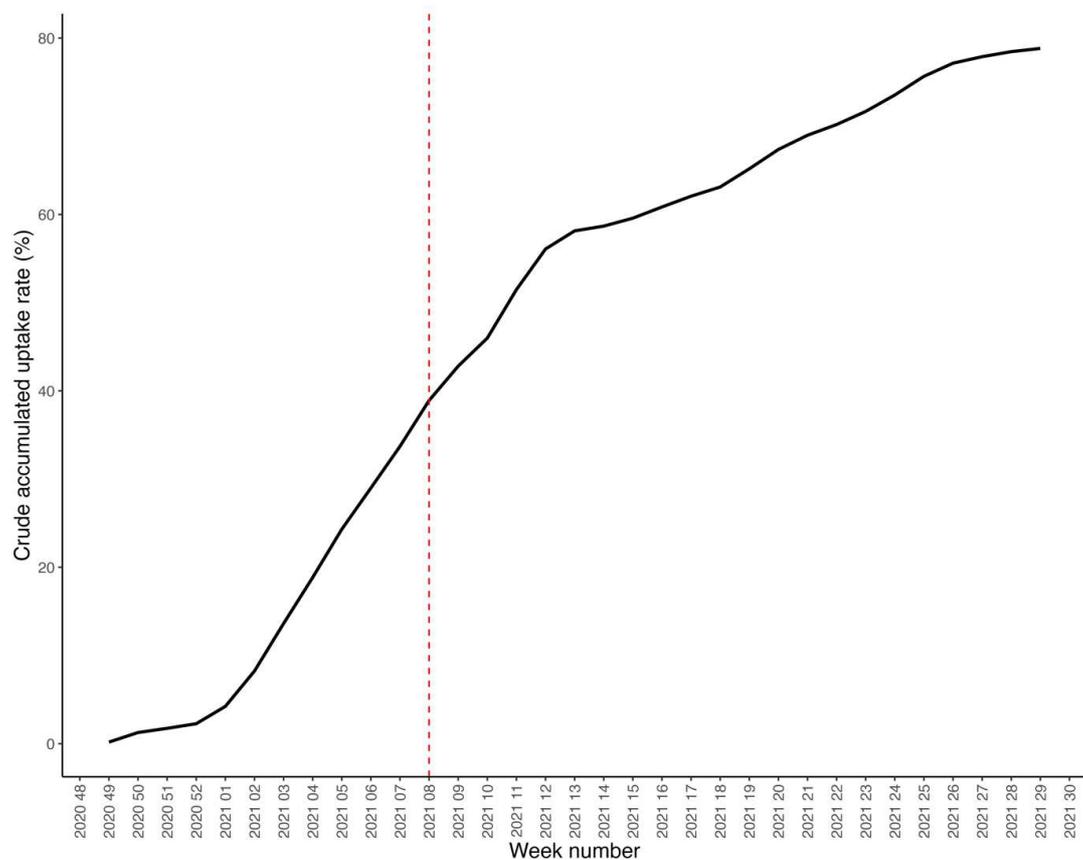
### Appendix 1. Timeline of the age eligibility for the rollout of the COVID-19 vaccine programme for the first dose in England.

**Table A1. The availability of vaccine appointments for the first dose of COVID-19 vaccine in England, by date.**

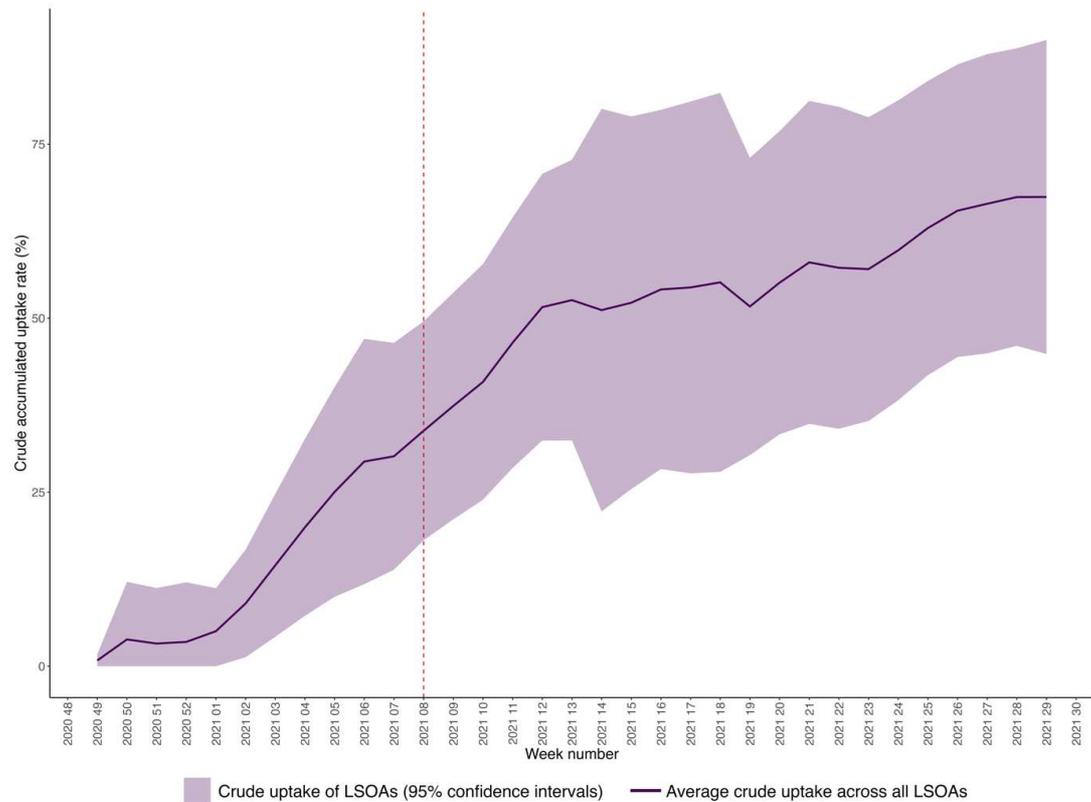
Start date	Appointments available for
8 December 2020	Residents in a care home for older adults and their carers; and all aged 80 and over
Procedures set out on 9 and 14 January 2021	Frontline health and social care workers
18 January 2021	All aged 70 and over, and clinically extremely vulnerable individuals
15 February 2021	All aged 65 and over; and those aged 16 to 64 with underlying health conditions which put them at higher risk of serious disease and mortality
1 March 2021	All aged 60 and over
6 March 2021	All aged 56 and over
17 March 2021	All aged 50 and over
13 April 2021	All aged 45 and over
26 April 2021	All aged 44 and over
27 April 2021	All aged 42 and over
30 April 2021	All aged 40 and over
13 May 2021	All aged 38 and over
18 May 2021	All aged 36 and over
20 May 2021	All aged 34 and over
22 May 2021	All aged 32 and over
26 May 2021	All aged 30 and over
8 June 2021	All aged 25 and over
15 June 2021	All aged 23 and over
16 June 2021	All aged 21 and over
18 June 2021	All adults (namely aged 18 and over)

Source: [COVID-19 vaccination in the United Kingdom - Wikipedia](#).

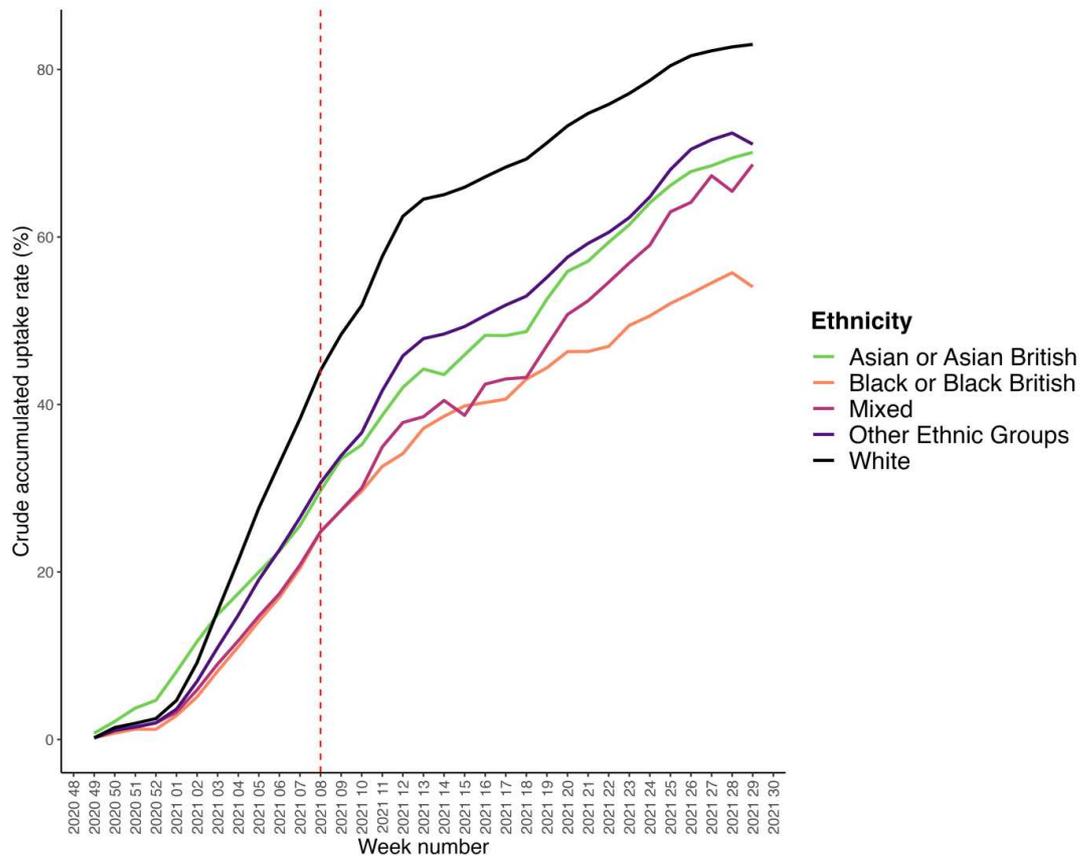
**Appendix 2. Crude and age-adjusted accumulated uptake of the COVID-19 vaccine first dose in Cheshire and Merseyside between the 49<sup>th</sup> week of 2020 (6<sup>th</sup> to 12<sup>th</sup> December 2020; the first COVID-19 vaccine was administered in the UK on 8<sup>th</sup> December 2020) and the 29<sup>th</sup> week of 2021 (18<sup>th</sup> to 24<sup>th</sup> July 2021; the end point of our study is 19<sup>th</sup> July 2021, three weeks after the last mobile vaccination unit visit on 28<sup>th</sup> June 2021).**



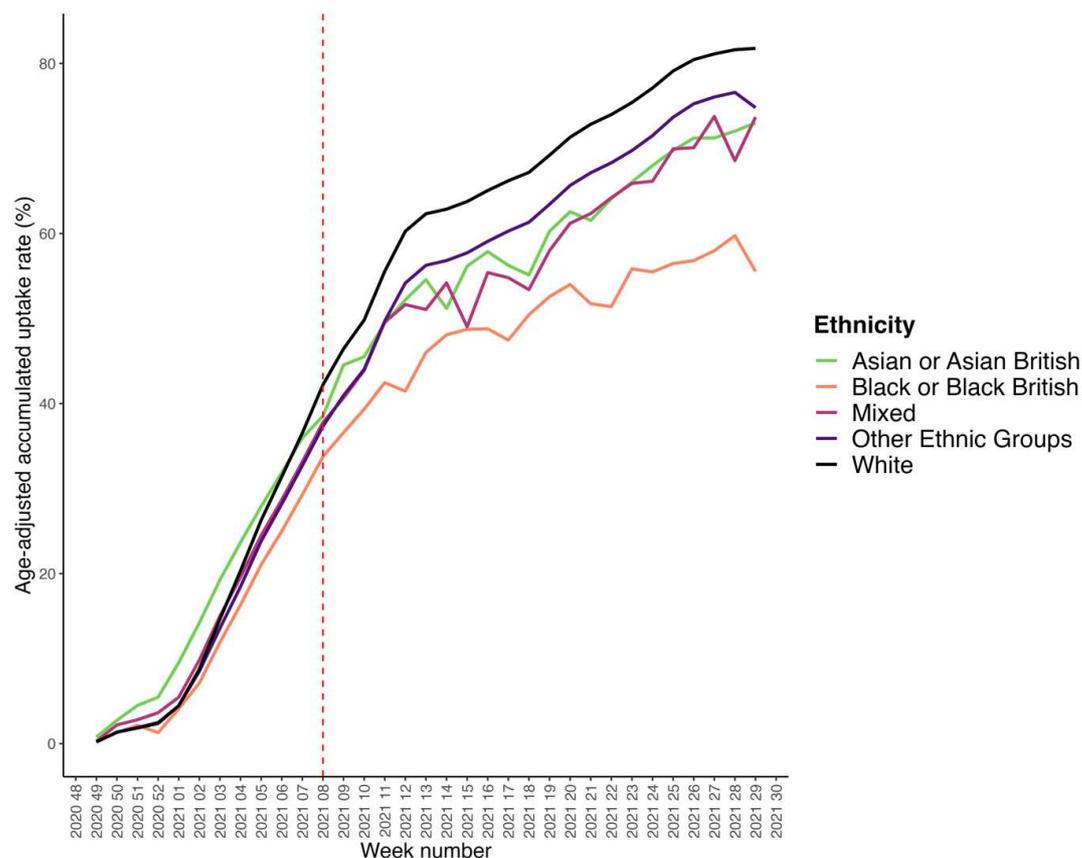
**Figure A1. Crude accumulated uptake rate of the first dose COVID-19 vaccine across Cheshire and Merseyside between the 49<sup>th</sup> week of 2020 and the 29<sup>th</sup> week of 2021. The dashed red vertical line represented the date of 22<sup>nd</sup> February 2021, the starting point of our study (seven weeks before the first mobile vaccination unit visit on 12<sup>th</sup> April 2021). After a relatively linear and stable growth between the 1<sup>st</sup> and 7<sup>th</sup> week of 2021, Cheshire and Merseyside started to see signs of slowing down in the crude uptake rate since the 8<sup>th</sup> week of 2021 (21<sup>st</sup> to 27<sup>th</sup> February 2021).**



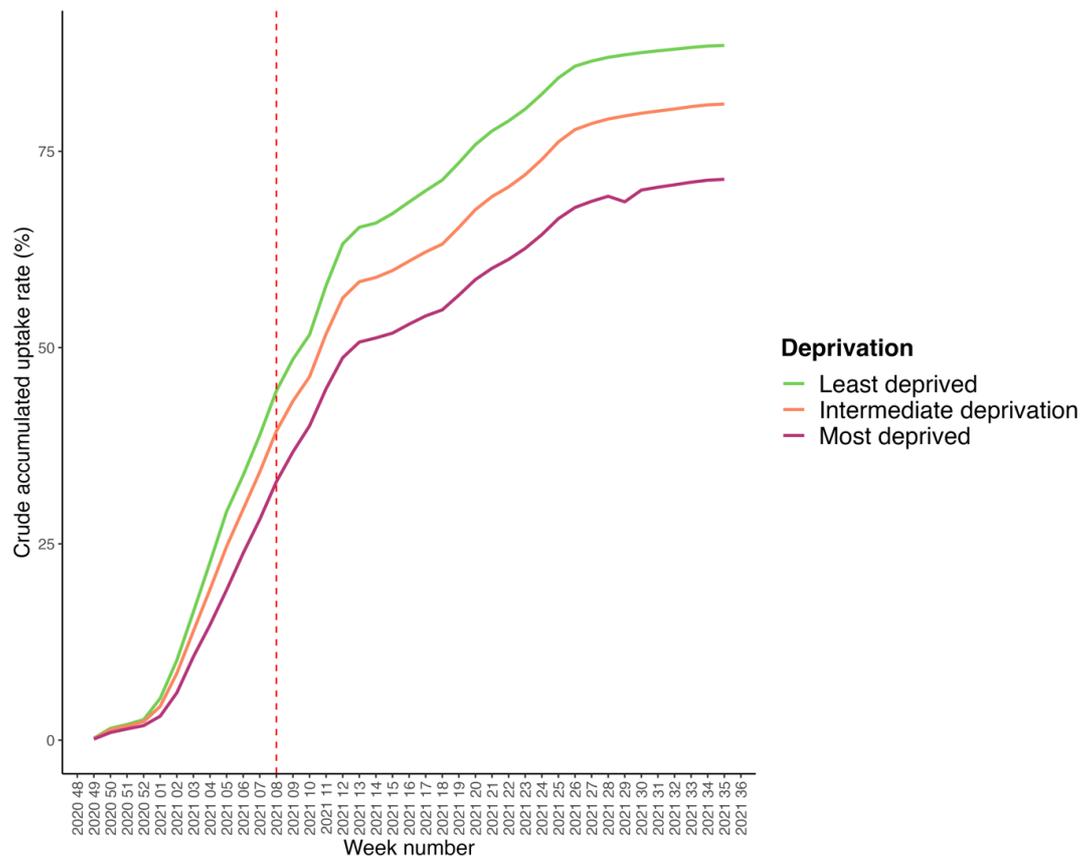
**Figure A2.** Average crude accumulated uptake rate of the first dose COVID-19 vaccine across all lower layer super-output areas (LSOAs) in Cheshire and Merseyside between the 49<sup>th</sup> week of 2020 and the 29<sup>th</sup> week of 2021, with its 95% confidence intervals. The dashed red vertical line represented the date of 22<sup>nd</sup> February 2021 (within the 8<sup>th</sup> week of 2021), the starting point of our study (seven weeks before the first mobile vaccination unit visit on 12<sup>th</sup> April 2021). Since the 8<sup>th</sup> week of 2021 (21<sup>st</sup> to 27<sup>th</sup> February 2021), LSOAs of Cheshire and Merseyside had seen expanding variations in their crude accumulated uptake of the first dose COVID-19 vaccine.



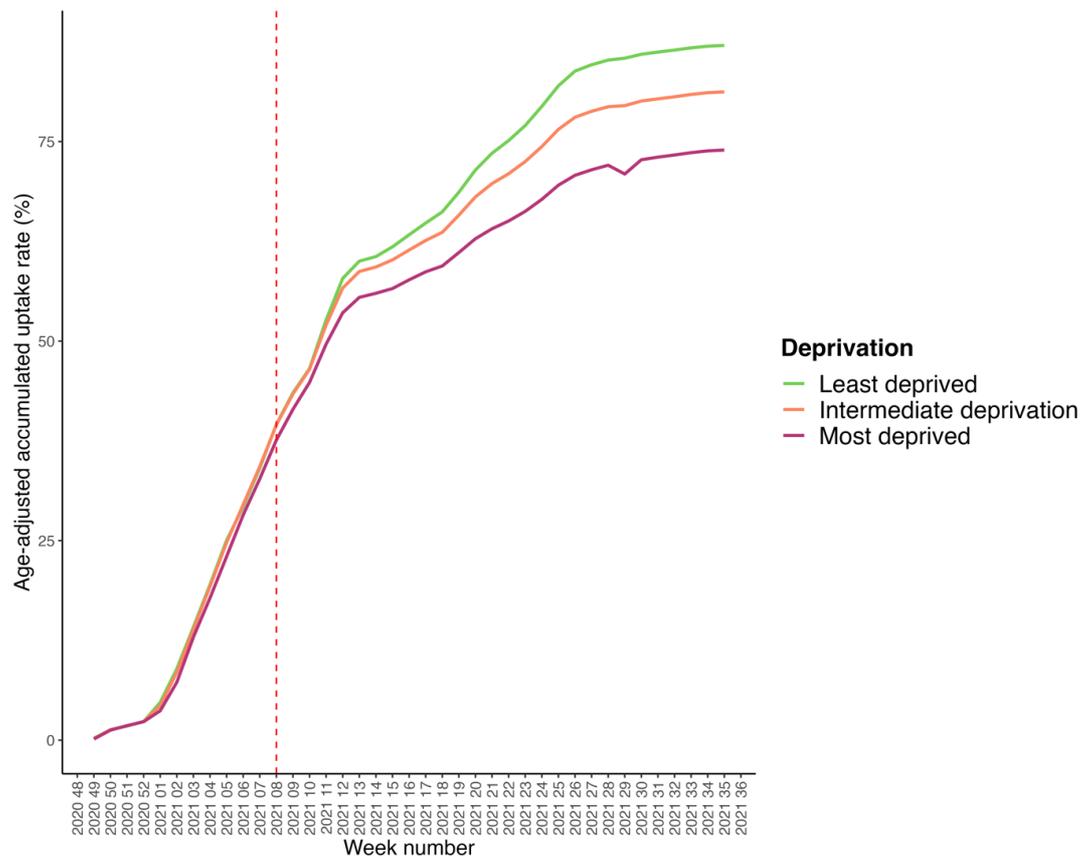
**A3. Crude accumulated uptake rate of the first dose COVID-19 vaccine among ethnic groups (White, Asian or Asian British, Black or Black British, Mixed, and Other) in Cheshire and Merseyside between the 49<sup>th</sup> week of 2020 and the 29<sup>th</sup> week of 2021. The dashed red vertical line represented the date of 22<sup>nd</sup> February 2021 (within the 8<sup>th</sup> week of 2021), the starting point of our study (seven weeks before the first mobile vaccination unit visit on 12<sup>th</sup> April 2021). Since the 8<sup>th</sup> week of 2021 (21<sup>st</sup> to 27<sup>th</sup> February 2021), ethnic groups of Cheshire and Merseyside had seen widening gaps in their crude accumulated uptake of the first dose COVID-19 vaccine.**



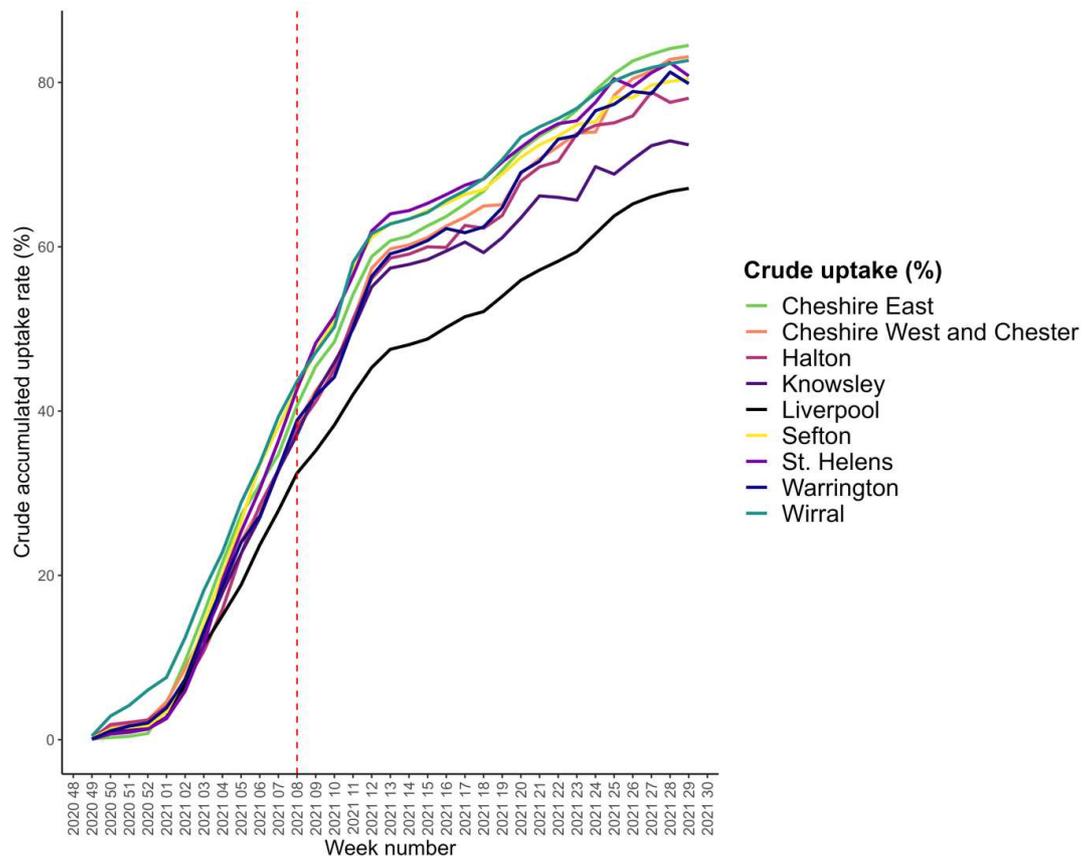
**A4. Age-adjusted accumulated uptake rate of the first dose COVID-19 vaccine among ethnic groups (White, Asian or Asian British, Black or Black British, Mixed, and Other) in Cheshire and Merseyside between the 49<sup>th</sup> week of 2020 and the 29<sup>th</sup> week of 2021. The dashed red vertical line represented the date of 22<sup>nd</sup> February 2021 (within the 8<sup>th</sup> week of 2021), the starting point of our study (seven weeks before the first mobile vaccination unit visit on 12<sup>th</sup> April 2021). The 8<sup>th</sup> week of 2021 (21<sup>st</sup> to 27<sup>th</sup> February 2021), as a turning point, had become pronounced for widening gaps in age-adjusted accumulated uptake of the first dose COVID-19 vaccine among ethnic groups in Cheshire and Merseyside.**



**A5. Crude accumulated uptake rate of the first dose COVID-19 vaccine among different socio-economic groups (Least deprived, Intermediate deprivation, and Most deprived) in Cheshire and Merseyside between the 49<sup>th</sup> week of 2020 and the 29<sup>th</sup> week of 2021. The dashed red vertical line represented the date of 22<sup>nd</sup> February 2021 (within the 8<sup>th</sup> week of 2021), the starting point of our study (seven weeks before the first mobile vaccination unit visit on 12<sup>th</sup> April 2021). Since the 8<sup>th</sup> week of 2021 (21<sup>st</sup> to 27<sup>th</sup> February 2021), different socio-economic groups of Cheshire and Merseyside had seen increasingly growing gaps in their crude accumulated uptake of the first dose COVID-19 vaccine.**



**A6. Age-adjusted accumulated uptake rate of the first dose COVID-19 vaccine among different socio-economic groups (Least deprived, Intermediate deprivation, and Most deprived) in Cheshire and Merseyside between the 49<sup>th</sup> week of 2020 and the 29<sup>th</sup> week of 2021. The dashed red vertical line represented the date of 22<sup>nd</sup> February 2021 (within the 8<sup>th</sup> week of 2021), the starting point of our study (seven weeks before the first mobile vaccination unit visit on 12<sup>th</sup> April 2021). Since the 8<sup>th</sup> week of 2021 (21<sup>st</sup> to 27<sup>th</sup> February 2021), different socio-economic groups of Cheshire and Merseyside had seen signs of widening gaps in their age-adjusted accumulated uptake of the first dose COVID-19 vaccine.**



**Figure A7. Crude accumulated uptake rate of the first dose COVID-19 vaccine by local authorities in Cheshire and Merseyside between the 49<sup>th</sup> week of 2020 and the 29<sup>th</sup> week of 2021. The dashed red vertical line represented the date of 22<sup>nd</sup> February 2021, the starting point of our study (seven weeks before the first mobile vaccination unit visit on 12<sup>th</sup> April 2021).**

### Appendix 3. Summary statistics of the intervention and full non-intervention population at the intervention onset in the 7 weeks prior to the introduction of the mobile vaccination unit.

Whilst Table 1 presents summary statistics for the intervention and non-intervention areas within the eight local authorities that reported data on the deployment (or non-deployment) of the mobile vaccination units and therefore are used to conduct the main analysis, Table A2 below shows the comparison between the intervention and the rest of the Cheshire and Merseyside, including the eight local authorities above and the one local authority with missing data on the intervention that has been excluded from the main analysis.

Table A2. The comparison between the intervention and the rest of Cheshire and Merseyside at the intervention onset in the 7 weeks prior to the introduction of the mobile vaccination unit.

	Rest of the Cheshire and Merseyside region	Intervention areas
Total population	1829809	338006
% women	50.72	48.92
Population density – people per hectare	34.88	65.11
Mean age	42.72	38.03
% Asian/Asian British	1.20	3.28
% Black/Black British	0.52	2.37
% Mixed people	1.39	1.87
IMD score	25.83	40.38
% households with at least one-bedroom fewer than they need	2.55	4.77
Average travel time by car to the nearest conventional static vaccine site - minutes	4.28	2.83
First dose vaccine uptake among adults (the percentage of adults who have received the first dose of COVID-19 vaccine among the total eligible adult population prior to pre-intervention) (%)	66.15	52.65

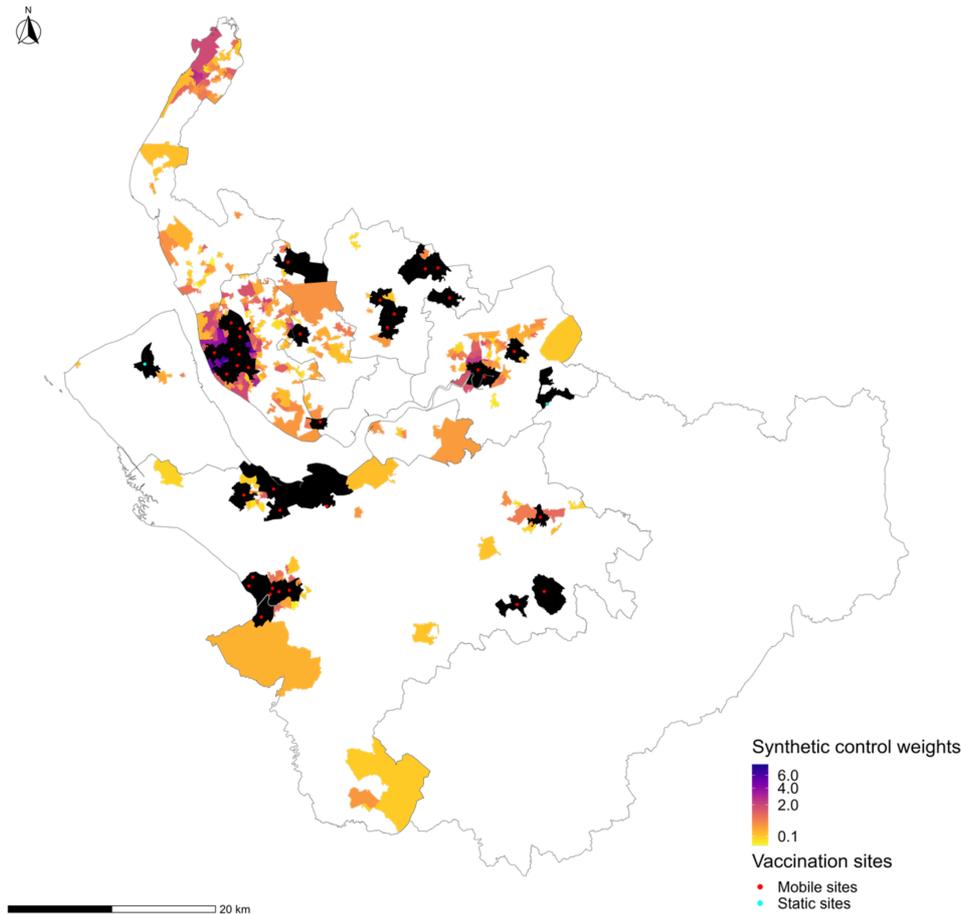
<b>Average weekly first dose vaccination rate among adults in the 7 weeks prior to intervention (%)</b>	2.08	1.51
<b>Number of LSOAs</b>	1346	216

**Appendix 4. The weekly number of the first dose administered in the intervention and control groups for each of the seven weeks prior to the intervention (the mobile vaccination unit).**

**Table A3. Weekly number of the first dose administered in the intervention and control groups for each of the seven weeks prior to the intervention (the mobile vaccination unit).**

<b>Weeks before the intervention</b>	<b>Weekly number of the first dose administered in the LSOAs being visited by the mobile vaccination units</b>	<b>Weekly number of the first dose administered in the LSOAs in the rest of Cheshire &amp; Merseyside used to construct the synthetic control</b>	<b>Weekly number of the first dose administered in the synthetic control (weighting LSOAs in the rest of Cheshire &amp; Merseyside using synthetic control weights)</b>
7	5692	31995	5692
6	5040	29288	5040
5	5256	31869	5256
4	5537	33022	5537
3	4730	24901	4730
2	4493	21180	4493
1	5059	21685	5059

## Appendix 5. Geographical pattern of weights in area-based synthetic control analysis.



**Figure A8. Weighting of areas outside of the catchment of the mobile vaccination units to construct the synthetic control group. Areas within the catchment of the mobile vaccination units are coloured black, whilst locations of the mobile vaccination unit are represented by red (35 mobile sites) and cyan (two static pop-up sites) dots. The white non-intervention areas are those that have been allocated zero weights in constructing the synthetic control, whilst other coloured non-intervention areas are those with non-zero weights in constructing the synthetic control: the darker the colour, the larger the weight.**

## **Appendix 6. Regression output for the interaction model based on adult individuals.**

Subgroup analysis by deprivation, ethnicity and age indicates, lower impact of the mobile vaccination unit on vaccination uptake for the most deprived areas compared to more affluent areas, a lower impact for Asian/Asian British, Black/Black British or Other ethnic groups, compared to white British people, and a lower impact on people aged 31-65-year-olds. The sample sizes are quite low for the subgroup analysis (see Appendix 7 below for more details) so the results reported here are only indicative of the overall pattern. Table A4 below shows the effect sizes of the mobile vaccination unit for the subgroups as relative risks. Compared to people not visited by the mobile vaccination units in their neighbourhoods, visits of the mobile vaccination units have increased vaccination rates in the following groups: people aged 18-30 from all socio-economic backgrounds and all ethnic groups except for Black/Black British; White/White British people aged above 30 from least and intermediate deprived areas; people aged 30-65 of mixed and other ethnic groups from the intermediate deprived areas; and people aged above 65 of mixed and other ethnic groups from least and intermediate deprived areas (see Figure 3 in the main text for more details).

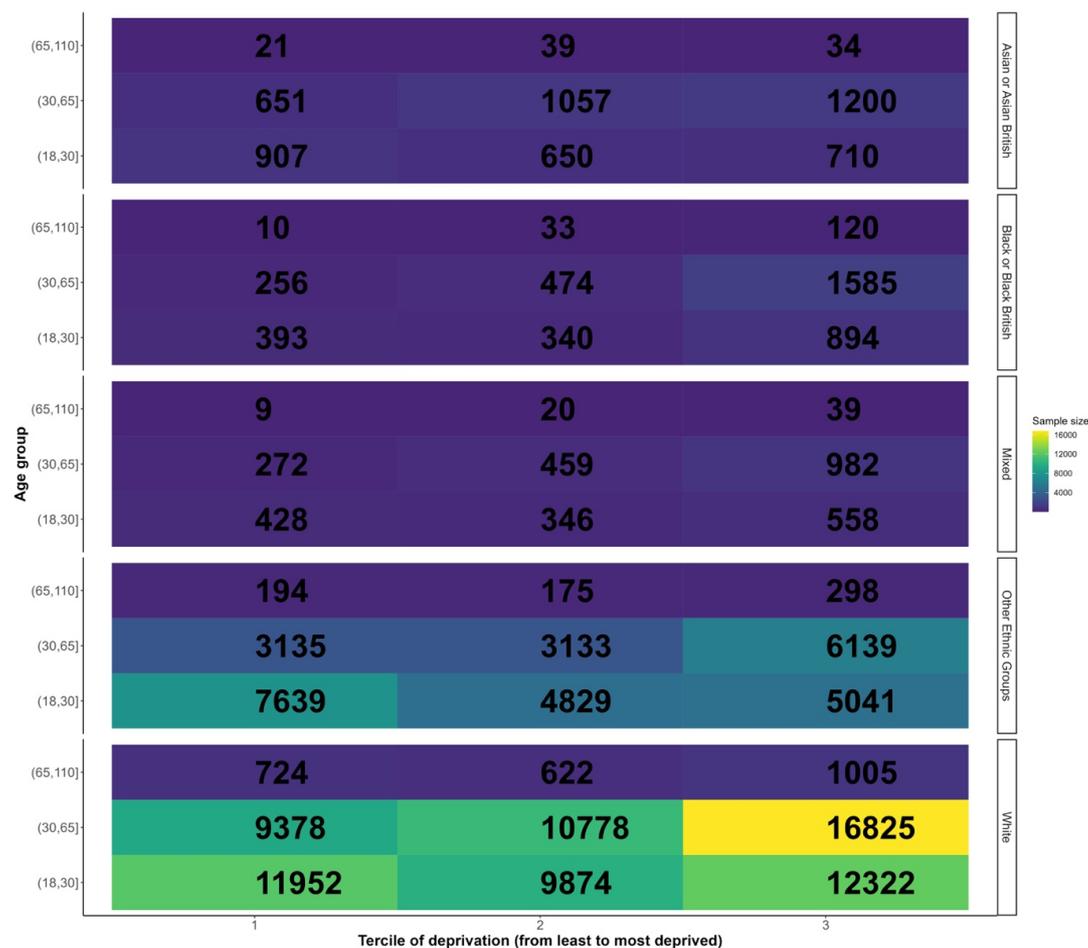
**Table A4. Regression output with interaction terms based on adult individuals. The table shows the relative risks indicating the estimated ratio of vaccine rates in the intervention group compared to the synthetic control group in the 3 weeks following intervention.**

Variables	RR	95% CI		p-value
		LCL	UCL	
<b>Mobile vaccination unit (reference: no mobile vaccination unit)</b>	1.683	1.584	1.789	<0.001
<b>Age group (reference: 18-30 years old)</b>				
<b>(30,65]</b>	1.249	1.187	1.313	<0.001
<b>65+</b>	0.201	0.147	0.275	<0.001
<b>Sex (reference: Women)</b>				
<b>Men</b>	1.013	0.984	1.042	0.380
<b>Ethnicity (reference: White/White British)</b>				
<b>Asian/Asian British</b>	0.919	0.791	1.068	0.271
<b>Black/Black British</b>	0.749	0.605	0.929	0.008
<b>Mixed</b>	0.746	0.608	0.915	0.005
<b>Other ethnic groups</b>	0.799	0.746	0.856	<0.001
<b>IMD tercile (reference: Least deprived)</b>				
<b>Intermediate deprivation</b>	0.786	0.741	0.834	<0.001
<b>Most deprived areas</b>	0.673	0.631	0.718	<0.001
<b>Chronic health conditions (reference: none)</b>	1.098	1.076	1.120	<0.001
<b>Carer (reference: not carer)</b>	0.320	0.273	0.375	<0.001
<b>Social care receiver (reference: not social care receiver)</b>	0.979	0.764	1.255	0.869
<b>Travel time by car to the nearest static vaccine centre (minutes)</b>	1.087	1.082	1.093	<0.001
<b>Interaction between age groups and mobile vaccination unit (reference: 18-30 years old with mobile vaccination unit)</b>				
<b>31-65 years old with mobile vaccination unit</b>	0.638	0.602	0.676	<0.001
<b>65+ years old with mobile vaccination unit</b>	0.700	0.475	1.030	0.070
<b>Interaction between ethnicity and mobile vaccination unit (reference: White/White British with mobile vaccination unit)</b>				
<b>Asian/Asian British with mobile vaccination unit</b>	0.788	0.664	0.935	0.006
<b>Black/Black British with mobile vaccination unit</b>	0.704	0.550	0.901	0.005

<b>Mixed with mobile vaccination unit</b>	0.900	0.712	1.138	0.379
<b>Other ethnic groups with mobile vaccination unit</b>	0.903	0.835	0.976	0.010
<b>Interaction between IMD tercile and mobile vaccination unit (reference: Least deprived with mobile vaccination unit)</b>				
<b>Intermediate deprivation with mobile vaccination unit</b>	1.081	1.010	1.158	0.024
<b>Most deprived areas with mobile vaccination unit</b>	0.770	0.715	0.829	<0.001
Note: The intercept is excluded from the output. We reported the result in three decimal digits specifically here to facilitate the explanation on how to interpret interaction terms.				

**Appendix 7. Sample size of the sub-groups (with visits of the mobile vaccination units) in the weighted Poisson model including interaction terms between the intervention indicator (mobile vaccination unit) and IMD tercile within Cheshire and Merseyside, ethnic and age groups respectively.**

**Figure A10. Heatmap of the sample size for each subgroup receiving the visit of the mobile vaccination units based on interaction analysis.**



**Appendix 8. Sensitivity test – excluding ethnicity from the main model.****Table A5. Results of analysis for adult individuals of all ages, excluding ethnicity.**

	RR	95% CI		p-value
		LCL	UCL	
<b>Model 2a. Individual level weighted Poisson regression analysis</b>	1.24	1.21	1.28	<0.001

Results of individual-level analysis presented in Table A5 and Table 2 are almost identical, implying that excluding cases with missing information on ethnicity did not affect the robustness of our results.

## Appendix 9. Sensitivity test – excluding the two pop-up sites across C&M.

**Table A6. Results of analysis for adult individuals of all ages, excluding the two pop-up sites.**

	RR	95% CI		p-value
		LCL	UCL	
<b>Model 2b. Individual level weighted Poisson regression analysis</b>	1.23	1.18	1.29	<0.001

Table A6 of individual-level analysis shows very similar results to those of Table 2, indicating that it is unlikely that the use of the two pop-up sites rather than vaccine buses alone influenced our results overall.

## Appendix 10. Sensitivity test – results of the synthetic control method based on different distance thresholds in constructing the synthetic control.

Table A7. Estimated effect of mobile vaccination units on weekly vaccine uptake (the percentage of adults who have received the first dose of the COVID-19 vaccine in a given week among the total eligible adult population), the table shows the relative risks indicating the estimated ratio of vaccine rates in the intervention group compared to the synthetic control group in the 3 weeks following intervention. Model 1a uses the 500 meter distance threshold to construct the intervention and non-intervention areas with LSOA level data, accounting for area-based differences between intervention and non-intervention areas, with permuted p-values and confidence intervals. Model 1b, 1c and 1d use the distance threshold of 1, 2 and 3KM respectively, all else equal.

	RR	95% CI		p-value
		LCL	UCL	
<b>Model 1a. LSOA level synthetic control analysis – 500-meter threshold</b>	1.10	-1.04	1.30	0.208
<b>Model 1b. LSOA level synthetic control analysis – 1500-meter threshold</b>	1.15	1.04	1.26	<0.001
<b>Model 1c. LSOA level synthetic control analysis – 2000-meter threshold</b>	1.05	-1.04	1.17	0.280
<b>Model 1d. LSOA level synthetic control analysis – 3000-meter threshold</b>	1.02	-1.12	1.19	0.888

Note: RR is relative risk. CI refers to confidence interval. LCL and UCL are the lower and upper confidence interval respectively.

**Appendix 11. Sensitivity test – results of the synthetic control method excluding LSOAs with centroids located between 1 to 1.5 km from the nearest mobile vaccination unit to account for the potential spatial spill over effect.**

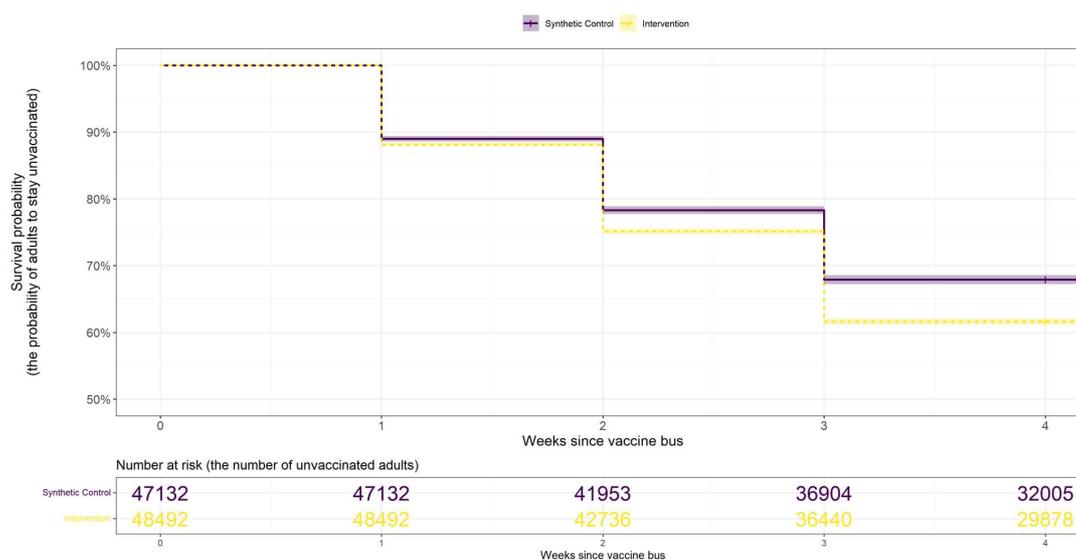
**Table A8. Estimated effect of mobile vaccination units on weekly vaccine uptake (the percentage of adults who have received the first dose of the COVID-19 vaccine in a given week among the total eligible adult population), the table shows the relative risks indicating the estimated ratio of vaccine rates in the intervention group compared to the synthetic control group in the 3 weeks following intervention. Model 1e uses the same distance threshold (1 km) as the main model 1 to construct the intervention and non-intervention areas with LSOA level data, but excludes LSOAs with population weighted centroids located between 1 and 1.5km from the nearest mobile vaccination unit to additionally account for the potential spatial spill over effect, with permuted p-values and confidence intervals.**

	RR	95% CI		p-value
		LCL	UCL	
<b>Model 1e. LSOA level synthetic control analysis – accounting for potential spatial spill over effect between 1 and 1.5 km</b>	1.24	1.11	1.40	<0.001

Note: RR is relative risk. CI refers to confidence interval. LCL and UCL are the lower and upper confidence interval respectively.

## Appendix 12. Sensitivity test – results of survival analyses based on adult individuals.

Using weights calibrated in the synthetic control analysis, we conducted a survival analysis to check the robustness of the synthetic control analysis. In this analysis, we compared the survival probability (the probability of adults to stay unvaccinated) between the synthetic control and intervention groups in the three weeks following the intervention, only including unvaccinated adults at the time of the intervention, a binary categorical variable indicating whether an individual had received the first-dose of the COVID-19 vaccine as the outcome variable, the number of week from the intervention as the time variable, and the variable of the intervention (the mobile bus units). Figure A8 below shows the survival curves of two groups and the risk table. Even without controlling for any individual-level confounders used in the main individual-level analysis, this model estimates 3487 additional vaccinations over three weeks of follow-up period ( $3487 = (32005-47132) - (29878-48492)$ ), broadly in line with the effect size estimated in the main analysis ( $n=3723$ ).



**Figure A9. The survival curves of the synthetic control (coloured in purple) and intervention groups (coloured in yellow) with their respective 95% confidence intervals and the risk table, following the same colouring scheme of Figure 2 in the main analysis.**

We then used a Cox proportional hazards regression model to replicate the sub-group analysis in Appendix 6. Results are shown in Table A9, similar to Table A4 in the overall trends and patterns.

**Table A10. Cox regression output for the interaction model based on adult individuals. The table shows the hazard ratio (HR) indicating the estimated ratio of weekly vaccination rates in the intervention group compared to the synthetic control group in the 3 weeks following intervention.**

Variables	HR	95% CI		p-value
		LCL	UCL	
<b>Mobile vaccination unit (reference: no mobile vaccination unit)</b>	1.83	1.72	1.95	<0.001
<b>Age group (reference: 18-30 years old)</b>				
<b>(30,65]</b>	2.16	2.05	2.29	<0.001
<b>65+</b>	1.49	1.08	2.06	0.017
<b>Sex (reference: Women)</b>				
<b>Men</b>	1.07	1.03	1.10	<0.001
<b>Ethnicity (reference: White/White British)</b>				
<b>Asian/Asian British</b>	0.83	0.71	0.98	0.027
<b>Black/Black British</b>	0.90	0.72	1.12	0.344
<b>Mixed</b>	0.77	0.62	0.96	0.021
<b>Other ethnic groups</b>	0.98	0.91	1.05	0.549
<b>IMD tercile (reference: Least deprived)</b>				
<b>Intermediate deprivation</b>	0.92	0.86	0.98	0.008
<b>Most deprived areas</b>	0.94	0.88	1.01	0.090
<b>Chronic health conditions (reference: none)</b>	0.97	0.95	0.99	0.013
<b>Carer (reference: not carer)</b>	0.67	0.56	0.80	<0.001
<b>Social care receiver</b>	1.02	0.79	1.30	0.894
<b>Travel time by car to the nearest static vaccine centre (minutes)</b>	1.04	1.04	1.05	<0.001
<b>Interaction between age groups and mobile vaccination unit (reference: 18-30 years old with mobile vaccination unit)</b>				
<b>31-65 years old with mobile vaccination unit</b>	0.65	0.61	0.69	<0.001
<b>65+ years old with mobile vaccination unit</b>	0.57	0.38	0.85	0.006
<b>Interaction between ethnicity and mobile vaccination unit (reference: White/White British with mobile vaccination unit)</b>				

<b>Asian/Asian British with mobile vaccination unit</b>	0.88	0.73	1.06	0.179
<b>Black/Black British with mobile vaccination unit</b>	0.70	0.54	0.90	0.006
<b>Mixed with mobile vaccination unit</b>	0.98	0.76	1.26	0.879
<b>Other ethnic groups with mobile vaccination unit</b>	0.98	0.91	1.07	0.670
<b>Interaction between IMD tercile and mobile vaccination unit (reference: Least deprived with mobile vaccination unit)</b>				
<b>Intermediate deprivation with mobile vaccination unit</b>	0.91	0.85	0.98	0.013
<b>Most deprived areas with mobile vaccination unit</b>	0.58	0.54	0.63	<0.001

Note: HR is hazard ratio. CI refers to confidence interval. LCL and UCL are the lower and upper confidence interval respectively.