Trends, regional variation, and clinical characteristics of COVID-19 vaccine recipients: a retrospective cohort study in 23.4 million patients using OpenSAFELY.

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NOTE: This preprint reports new research that has not been certified by peer review and should not be used to guide clinical practice.
Abstract

Background
On December 8th 2020, NHS England administered the first COVID-19 vaccination as part of an ambitious vaccination programme during a global health emergency.

Aims
To develop a framework for detailed near-real-time monitoring of COVID-19 vaccine roll-out; to describe trends and variation in coverage by geographic area, and between key clinical and demographic patient groups.

Methods
Working on behalf of NHS England we used routine clinical data from 23.4 million patients to conduct a retrospective cohort study of comprehensive electronic health record data in NHS England, using the OpenSAFELY-TPP platform which covers approximately 40% of the general population in England with weekly data updates. We developed algorithms to identify key demographic and clinical sub-groups within this population and generated descriptive statistics on proportion of eligible patients receiving the vaccine among key Joint Committee on Vaccination and Immunisation (JCVI) target groups.

Results
Between December 8th and January 13th 961,580 people out of 23.4m in our dataset received a COVID-19 vaccine. Of 1,160,062 patients aged 80 or over and not living in a care home (currently targeted by JCVI) 476,375 had been vaccinated in total (41.1%). We observed a substantial divergence in vaccination by ethnicity within this group (White 42.5% vaccinated, Black 20.5%) and across rankings of deprivation (least deprived 44.7%, most deprived 37.9%). Patients with pre-existing medical conditions were equally likely, or more likely, to have received a vaccine across most co-morbidity groups with two exceptions: severe mental illness (30.3% vaccinated) and learning disability (28.1%). We identify substantial variation in vaccination among the over-80s between Sustainability and Transformation Partnerships (STPs; Range 12%-74%); lower vaccination rates among ethnic minority and deprived groups was observed in most but not all STPs. In the 70-79 age cohort 74,108 people (3.6%) had been vaccinated. 378,921 vaccine recipients under 70 and not identifiably resident in a care home were presumed to be health or social care workers; 32,174 recipients were identified as older aged care home residents (33.2% coverage). Of all those vaccinated, 169,472 had received a second dose (17.6%).

Conclusions
The NHS in England has rapidly delivered mass vaccination. We were able to deploy a data monitoring framework across small clinical subgroups using linked patient-level NHS data on 23.4 million people with very short delays from vaccine administration to completed analysis. Targeted activity may be needed to address lower vaccination rates observed among certain key groups: ethnic minorities, people living in areas of higher deprivation, and those with severe mental illness or learning disabilities. However we note that this data is only from the first preliminary weeks of the vaccination programme. Variation in vaccination coverage between groups and regions will have many complex drivers, the figures presented in this manuscript require thoughtful interpretation to support a rapidly evolving NHS vaccination campaign; we are sharing local level data with national and regional NHS teams on request.

Keywords: Vaccination, COVID-19, SARS-CoV-2, NHS England
Background

On December 8th 2020, the NHS in England administered the first COVID-19 vaccination as part of an ambitious vaccination programme to combat the ongoing pandemic due to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Vaccination is one of the most cost-effective ways of avoiding disease and worldwide vaccinations prevent 2-3 million deaths per year, but new vaccines can take many years or decades to develop and become part of routine practice [1]. Since the outset of the COVID-19 pandemic, teams of scientists, clinical trialists and regulators around the world have worked at unprecedented speed, with more than 200 vaccines currently being tested [2]. The UK medicines regulator approved two COVID-19 vaccines for use before the end of 2020, the Pfizer-BioNTech mRNA vaccine and the AstraZeneca-Oxford vaccine, with the Moderna vaccine being the third vaccine approved on January 8th and more vaccine approvals expected in 2021 [3,4].

In the UK, the independent expert body Joint Committee on Vaccination and Immunisation (JCVI) provides recommendations on vaccinations to the government and England’s National Health Service (NHS). In early December 2020 the JCVI recommended priority groups for vaccination (box 1), largely based on risk of death from COVID-19 [5] which NHS England set about implementing. Despite their top priority status, it was not expected that there would be widespread vaccination of care home residents, given that the first available vaccine (Pfizer-BioNTech) was difficult to distribute, but this became more practical when the AstraZeneca-Oxford vaccine became widely available from early January [6]. Vaccinations were administered initially in hospitals and a small number of primary care centres, and are now additionally being administered in newly established mass vaccination centres, GP surgeries and community pharmacies. The details of all administered vaccinations are in principle automatically sent to every person’s GP, as well as being recorded in the National Immunisation Management Service (NIMS). Both vaccines approved to date require two doses, which, in trials, were issued approximately three to four weeks apart. Given high infection rates and the relatively high protection thought to be offered by the first dose, after the start of the campaign the JCVI recommended extending the interval to 12 weeks. This strategy was intended to prevent the most deaths and hospitalisations through maximising the number of people with some protection against the virus as quickly as possible, although GPs were initially allowed some discretion in the exact timing of the second dose [7,8].

OpenSAFELY is a new secure analytics platform for electronic patient records built by our group on behalf of NHS England to deliver urgent academic and operational research during the pandemic [9,10]: analyses can currently run across all patients’ full raw pseudonymised primary care records at 40% of English general practices where TPP electronic health record software is deployed, with patient-level linkage to various sources of secondary care data; code and analysis is shared openly for inspection and re-use.

We therefore set out to: assess the coverage of COVID-19 vaccines to people registered with OpenSAFELY-TPP practices, in as close to real-time as the available data can support; and to describe how coverage varied between key clinical, regional, and demographic subgroups.
Box 1 – *Priority groups for vaccination advised by the Joint Committee on Vaccination and Immunisation* [5]

| Priority Group | Risk group |
|----------------|------------|
| 1              | Residents in a care home for older adults  
                      Staff working in care homes for older adults |
| 2              | All those 80 years of age and over  
                      Frontline Health and social care workers |
| 3              | All those 75 years of age and over |
| 4              | All those 70 years of age and over  
                      Clinically extremely vulnerable individuals (not including pregnant women and those under 16 years of age) |
| 5              | All those 65 years of age and over |
| 6              | Adults aged 16 to 65 years in an at-risk group |
| 7              | All those 60 years of age and over |
| 8              | All those 55 years of age and over |
| 9              | All those 50 years of age and over |
Methods

Study design

We conducted a retrospective cohort study using general practice primary care electronic health record data from NHS England. The cohort study began on 7th December 2020, chosen as the day before the start of the national vaccination campaign and ended on January 13th to produce this analysis. We will update this analysis regularly with extended follow-up time using our near real time data as the vaccination campaign progresses.

Data Source

Primary care records managed by the GP software provider TPP were accessed through OpenSAFELY-TPP, an open source data analytics platform created by our team on behalf of NHS England to address urgent COVID-19 research questions (https://opensafely.org). OpenSAFELY-TPP provides a secure software interface allowing the analysis of pseudonymized primary care patient records from England in near real-time within the EHR vendor’s highly secure data centre, avoiding the need for large volumes of potentially disclosive pseudonymised patient data to be transferred off-site. This, in addition to other technical and organisational controls, minimizes any risk of re-identification. Similarly pseudonymized datasets from other data providers are securely provided to the EHR vendor and linked to the primary care data, such as Office of National Statistics (ONS) death data. The dataset analysed within OpenSAFELY-TPP is based on 23.4 million people currently registered with GP surgeries using TPP SystmOne software to record and retrieve patient information. It includes pseudonymised data such as coded diagnoses, medications and physiological parameters. No free text data are included. Further details on our information governance can be found under information governance and ethics.

Study population

We included all people registered with a TPP general practice in England on December 7th 2020 who had no record of death in ONS up to the same date.

Assessing the coverage of COVID-19 vaccines

Vaccination information is transmitted back to patients’ primary care records over the days following administration. We ascertained which patients had any recorded COVID-19 vaccine administration in the mirror of their primary care record held in OpenSAFELY-TPP (only Pfizer-BioNTech mRNA vaccine or AstraZeneca-Oxford vaccine were available to patients at the time of analysis). We included those vaccinated up to January 13th 2021, the latest available vaccinations recorded in the most recent OpenSAFELY-TPP database build, on January 17th (data completeness may be affected by late reporting of some vaccinations). We classed any subsequent COVID-19 vaccinations within 19 days of the first dose as a duplicate record entry, and those vaccinations after this date as the second dose of the schedule.
Key demographic and clinical characteristics of vaccinated groups

We classified patients by age group and care home residence status, and other key demographics including ethnicity and the level of deprivation. Deprivation was measured by the Index of Multiple Deprivation (IMD, in quintiles, with higher values indicating greater deprivation), derived from the patient’s postcode at lower super output area level for a high degree of precision. Ethnicity was ascertained using 270 clinical codes grouped into broad categories (White, Black, Asian or Asian British, Mixed, Other, or Unknown) and additionally more specific categories for more detailed analysis [11]. For over 65s we also identified whether they were resident in an elderly care home at the start of the vaccination campaign, both as a JCVI priority group in itself and also to exclude care home residents from the groupings by age band. Occupation is not routinely and systematically recorded by GPs in England; we assumed, due to eligibility criteria at this point in the vaccination campaign, that those under 70 and not resident in a care home were health or social care workers.

We also describe the population according to the presence or absence of various pre-existing health problems: chronic cardiac disease; chronic obstructive pulmonary disease (COPD); obesity (most recent adult body mass index (BMI) ≥30); dialysis; Disease-Modifying Anti-Rheumatic Drugs (DMARDS); psychosis, severe mental illness (schizophrenia and bipolar disorder); learning disabilities including Down syndrome; dementia; chemotherapy or radiotherapy; lung cancer; haematological cancer; other cancers; and SSRI usage (to identify people with common mental health problems such as depression and anxiety). Information on all characteristics were obtained from primary care records by searching TPP SystmOne records for specific coded data. TPP SystmOne allows users to work with the SNOMED-CT clinical terminology, using a GP subset of SNOMED-CT codes. This subset maps on to the native Read version 3 (CTV3) clinical coding system that SystmOne is built on. Medicines are entered or prescribed in a format compliant with the NHS Dictionary of Medicines and Devices (dm+d) [12], a local UK extension library of SNOMED-CT. Code lists for particular underlying conditions and medicines were compiled from a variety of sources. Detailed information on compilation and sources for every individual codelist is available at https://codelists.opensafely.org/. We generated step charts of vaccine coverage for all underlying conditions and medicines. Those not presented in this manuscript are available online for inspection in the associated GitHub repository [13].

Geographic variation in coverage
Practices in OpenSAFELY-TPP were each linked to their local Sustainability and Transformation Partnership (STP; NHS administrative regions) as at March 2020. We calculated the percentage of the over 80 population covered by OpenSAFELY-TPP for each STP as of March 2020; STPs were excluded where this was less than 10%. We calculated vaccination coverage rates for all remaining STPs. We have generated STP level reports of all national step line charts presented in this manuscript. We are currently discussing with the NHS the best way to systematically disseminate these reports to STP level teams; these charts are available on request to STP teams by contacting team@opensafely.org.

Software and Reproducibility
Data was accessed through the OpenSAFELY-TPP platform, as per Supplementary Materials. Data management and analysis was performed using the OpenSAFELY software
libraries and Jupyter notebooks, both implemented using Python3. Code for data management and analysis for this paper is shared for scientific review and re-use under open licenses on GitHub (https://github.com/opensafely/nhs-covid-vaccination-uptake). All codelists are available for inspection and re-use from https://codelists.opensafely.org, most codelists were re-used from prior OpenSAFELY analyses. All code for the OpenSAFELY platform for data management, analysis and secure code execution is shared for review and re-use under open licenses at GitHub.com/OpenSAFELY.

Patient and Public Involvement
Patients were not formally involved in developing this specific study design that was developed rapidly in the context of the rapid vaccine rollout during a global health emergency. We have developed a publicly available website https://opensafely.org/ through which we invite any patient or member of the public to contact us regarding this study or the broader OpenSAFELY project.
Results

COVID-19 vaccine coverage

961,580 people registered at a TPP practice in England received a COVID-19 vaccine up to 13th January 2021 (Figure 1). Of these, 476,375 were over 80 (representing 41.1% of all over 80s not identified as residing in care homes and currently registered at a TPP practice); 74,108 were aged 70-79 (3.6% coverage); 378,921 were presumed on the basis of age to be health or social care workers (i.e. under 70, non-care home residents); and 32,174 were identified as care home residents (aged 65+, 33.2% coverage). Of all those vaccinated, 169,472 have received a second dose (17.6%) and 65,055 received the AstraZeneca-Oxford vaccine as their first dose (6.8%) with the remainder receiving the Pfizer-BioNTech vaccine.

Figure 1 - Cumulative total of COVID-19 vaccinations recorded in OpenSAFELY-TPP on January 13th 2021.

Key demographic and clinical characteristics of vaccinated groups

The proportion of eligible people aged over 80 in each demographic and clinical category who were vaccinated by January 13th 2021 is presented in Table 1 and Figures 2 and 3 below. Vaccination was less common among those living in the most deprived postcode areas (37.9% in the most deprived quintile compared to 44.7% in the least deprived figure 2a). Across broad ethnic groups (figure 2b), the proportion vaccinated to date was highest among white people (42.6%); lowest among among black people (20.5%); 27.0%-29.5% among people of mixed, other and South Asian ethnicities; and 39.7% among those with unknown ethnicity; ethnicity coding was complete for 71.9% of people in this age group. Vaccination rates were very similar in those with and without obesity (figure 3a) but slightly
higher among people with physical comorbidities such as chronic cardiac disease (figure 3b), COPD, or cancer (Appendix 1 - figures). However, rates were substantially lower among those with severe mental illness (30.3%, figure 3c) learning disabilities (28.1%, figure 3d), dementia (30.9%, figure 3e) and slightly lower among those prescribed SSRI antidepressants in the last year (appendix 1 - figures).

Table 1. COVID vaccinations among 80+ population not resident in care homes as at 13th Jan 2021. Values <7 suppressed. Patient counts are rounded to the nearest 7. “coverage over last 7d” is the absolute percentage increase in coverage since the previous week.

| Category                  | Group                      | Vaccinated at 13th Jan (n) | Vaccinated at 13th Jan (%) | Total Vaccinated at 6th Jan 2021 (%) | coverage over last 7d (%) |
|---------------------------|----------------------------|---------------------------|---------------------------|--------------------------------------|--------------------------|
| Overall                   | Overall                    | 476,376                   | 41.1                      | 1,160,062                            | 24.5                     | 16.6                     |
| Sex                       | F                          | 265,076                   | 39.6                      | 669,278                              | 23.2                     | 16.4                     |
|                           | M                          | 211,295                   | 43.1                      | 490,774                              | 26.3                     | 16.8                     |
| Ethnicity broad categories| Black                      | 2,121                     | 20.5                      | 10,329                               | 11.6                     | 8.9                      |
|                           | Mixed                      | 756                       | 27.0                      | 2,805                                | 16.2                     | 10.8                     |
|                           | Other                      | 1,498                     | 27.0                      | 5,539                                | 15.8                     | 11.2                     |
|                           | South Asian                | 7,945                     | 29.5                      | 26,936                               | 17.7                     | 11.8                     |
|                           | Unknown                    | 129,199                   | 39.7                      | 325,637                              | 23.3                     | 16.4                     |
|                           | White                      | 334,852                   | 42.5                      | 788,806                              | 25.5                     | 17.0                     |
|                           | African                    | 329                       | 15.9                      | 2,072                                | 9.5                      | 6.4                      |
|                           | Bangladeshi or British     | 287                       | 23.0                      | 1,250                                | 12.3                     | 10.7                     |
|                           | Bangladeshi                |                           |                           |                                      |                          |                          |
|                           | Caribbean                  | 1,533                     | 21.8                      | 7,045                                | 12.1                     | 9.7                      |
|                           | Chinese                    | 497                       | 31.9                      | 1,558                                | 18.9                     | 13.0                     |
|                           | Other                      | 1,001                     | 25.1                      | 3,981                                | 14.6                     | 10.5                     |
|                           | Other Asian                | 1,204                     | 28.8                      | 4,179                                | 16.4                     | 12.4                     |
|                           | British or Mixed British   | 317,037                   | 42.8                      | 740,996                              | 25.7                     | 17.1                     |
|                           | Indian or British Indian   | 4,781                     | 33.8                      | 14,159                               | 20.9                     | 12.9                     |
|                           | Irish                      | 3,346                     | 41.2                      | 8,126                                | 25.2                     | 16.0                     |
|                           | Other Black                | 252                       | 20.8                      | 1,212                                | 12.1                     | 8.7                      |
|                           | Other White                | 14,462                    | 36.4                      | 39,684                               | 21.1                     | 15.3                     |
|                           | Other mixed                | 259                       | 30.9                      | 839                                  | 19.2                     | 11.7                     |
|                           | Pakistani or British       | 1,673                     | 22.8                      | 7,348                                | 13.3                     | 9.5                      |
|                           | Pakistani                  |                           |                           |                                      |                          |                          |
|                           | Unknown                    | 129,199                   | 39.7                      | 325,637                              | 23.3                     | 16.4                     |
|                           | White + Asian              | 168                       | 35.7                      | 471                                  | 23.8                     | 11.9                     |
|                           | White + Black African      | 77                        | 20.9                      | 368                                  | 13.3                     | 7.6                      |
|                           | White + Black Caribbean    | 252                       | 22.4                      | 1,127                                | 11.8                     | 10.6                     |
| Index of Multiple Deprivation | 1 Most deprived        | 57,393                    | 37.9                      | 151,255                               | 22.8                     | 15.1                     |
|                           | 2                          | 76,223                    | 39.2                      | 194,657                               | 23.8                     | 15.4                     |
|                           | 3                          | 100,996                   | 39.0                      | 259,041                               | 23.2                     | 15.8                     |
|                           | 4                          | 112,749                   | 42.2                      | 266,905                               | 25.3                     | 16.9                     |
|                           | 5 Least deprived           | 119,567                   | 44.7                      | 267,454                               | 26.1                     | 18.6                     |
|                           | Unknown                    | 9,443                     | 45.5                      | 20,740                               | 29.2                     | 16.3                     |
| BMI                       | 30+                        | 84,000                    | 41.2                      | 203,700                               | 24.8                     | 16.4                     |
|                           | under 30                   | 392,371                   | 41.0                      | 956,352                               | 24.4                     | 16.6                     |
| Chronic cardiac disease   | no                         | 333,459                   | 40.9                      | 814,701                               | 24.2                     | 16.7                     |
|                           | yes                        | 142,912                   | 41.4                      | 345,351                               | 25.1                     | 16.3                     |
Figure 2. Trends in demographic features of the 80+ population receiving their first COVID vaccination, cumulatively by day. *National cohort rate calculated as at latest date for vaccinations recorded across all TPP practices.

(a) COVID vaccinations among 80+ population by Index of Multiple Deprivation ¶

| Current COPD      | no     | 424,641 | 40.9  | 1,037,745 | 24.3  | 16.6  |
|-------------------|--------|---------|-------|-----------|-------|-------|
|                   | yes    | 51,730  | 42.3  | 122,307   | 26.2  | 16.1  |
| Dialysis          | no     | 475,482 | 41.1  | 1,157,832 | 24.5  | 16.6  |
|                   | yes    | 889     | 40.0  | 2,220     | 25.5  | 14.5  |
| DMARDs (ever)     | no     | 461,223 | 41.0  | 1,124,310 | 24.4  | 16.2  |
|                   | yes    | 15,148  | 42.4  | 35,742    | 26.2  | 16.2  |
| Dementia          | no     | 470,274 | 41.2  | 1,140,315 | 24.6  | 16.6  |
|                   | yes    | 6,097   | 30.9  | 19,737    | 16.5  | 14.4  |
| Psychosis         | no     | 473,620 | 41.2  | 1,150,959 | 24.6  | 16.6  |
| Schizophrenia     | yes    | 2,751   | 30.3  | 9,093     | 16.9  | 13.4  |
| Learning disability incl Down syndrome | no | 475,874 | 41.1  | 1,158,286 | 24.5  | 16.6  |
|                   | yes    | 497     | 28.1  | 1,766     | 15.1  | 13.0  |
| SSRIs (in past year) | no  | 442,365 | 41.3  | 1,070,381 | 24.7  | 16.6  |
|                   | yes    | 34,013  | 37.9  | 89,671    | 22.2  | 15.7  |
| Chemo or radiotherapy (ever) | no | 459,634 | 41.0  | 1,121,226 | 24.4  | 16.6  |
|                   | yes    | 16,737  | 43.1  | 38,826    | 26.5  | 16.6  |
| Lung cancer       | no     | 473,186 | 41.1  | 1,152,173 | 24.5  | 16.6  |
|                   | yes    | 3,185   | 40.4  | 7,879     | 25.6  | 14.8  |
| Cancer excl lung and haem | no | 387,961 | 40.7  | 954,235   | 24.1  | 16.6  |
|                   | yes    | 88,410  | 43.0  | 205,817   | 26.2  | 16.8  |
| Haematological cancer | no | 467,061 | 41.0  | 1,138,825 | 24.4  | 16.6  |
|                   | yes    | 9,310   | 43.9  | 21,227    | 27.3  | 16.6  |

| Chemo or radiotherapy (ever) |
|-----------------------------|
| no  | 459,634 | 41.0  | 1,121,226 | 24.4  | 16.6  |
| yes | 16,737  | 43.1  | 38,826    | 26.5  | 16.6  |

| Lung cancer |
|-------------|
| no  | 473,186 | 41.1  | 1,152,173 | 24.5  | 16.6  |
| yes | 3,185   | 40.4  | 7,879     | 25.6  | 14.8  |

| Cancer excl lung and haem |
|---------------------------|
| no  | 387,961 | 40.7  | 954,235   | 24.1  | 16.6  |
| yes | 88,410  | 43.0  | 205,817   | 26.2  | 16.8  |

| Haematological cancer |
|-----------------------|
| no  | 467,061 | 41.0  | 1,138,825 | 24.4  | 16.6  |
| yes | 9,310   | 43.9  | 21,227    | 27.3  | 16.6  |
(b) COVID vaccinations among 80+ population by Ethnicity (broad categories)

![Graph showing trends in clinical characteristics of the 80+ population receiving their first COVID vaccination, cumulatively by day. *National rate calculated as at latest date for vaccinations recorded across all TPP practices.*](image)

**Figure 3.** Trends in clinical characteristics of the 80+ population receiving their first COVID vaccination, cumulatively by day. *National rate calculated as at latest date for vaccinations recorded across all TPP practices.*

(a) COVID vaccinations among 80+ population by ‘BMI’

![Graph showing trends in clinical characteristics of the 80+ population receiving their first COVID vaccination, cumulatively by day. *National rate calculated as at latest date for vaccinations recorded across all TPP practices.*](image)
b) COVID vaccinations among 80+ population by ‘current COPD’

![Graph showing COVID vaccinations among 80+ population by 'current COPD'.]

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c) COVID vaccinations among 80+ population by ‘psychosis, schizophrenia and bipolar’

![Graph showing COVID vaccinations among 80+ population by 'psychosis, schizophrenia and bipolar'.]

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d) COVID vaccinations among 80+ population by ‘learning disability including Down syndrome’

![Graph showing COVID vaccinations among 80+ population by 'learning disability including Down syndrome'.]
e) COVID vaccinations among 80+ population by ‘dementia’

Geographic variation in coverage

We calculated vaccination coverage among over 80s for 25 of England’s 42 STPs (60%), excluding those where data was available within OpenSAFELY-TPP for less than 10% of patients aged over 80; we have data for 20%-95% of the 80+ population in each included STP. Substantial variation in vaccination coverage was observed (range = 12%-74%). We compared coverage between white and black populations in each STP, these being the ethnicities with the greatest overall disparity. Most STPs had higher vaccination coverage amongst the white group compared with the black group (17/25, after accounting for uncertainty caused by small number suppression/rounding); among these 18 STPs the mean disparity was 21.5%; however, the greatest disparity was over 31% (32.1 +/-1.0%). The direction of disparity was uncertain in the remaining STPs, and some STPs may have greater disparities between other ethnic groups. The vast majority of STPs (20/25) similarly had higher vaccination coverage across those aged 80+ living in the least deprived areas than the most deprived areas, but this disparity was generally smaller (mean 11.9%). Five STPs had higher coverage in the most deprived areas.
Discussion

Summary
The NHS in England has rapidly responded to the availability of COVID-19 vaccines and administered a substantial number of doses in the first six weeks of the vaccination campaign. In our study 961,580 people had received at least one vaccine dose by January 13th, including 41.1% of eligible people over the age of 80. Over 80s from ethnic minority groups were substantially less likely to be vaccinated in the first weeks of the COVID-19 vaccination campaign, and similarly those living in more socioeconomically deprived areas generally had lower vaccine coverage. Among those over 80, people with pre-existing medical conditions were equally likely, or more likely, to have received a vaccine, across all groups of pre-existing medical problems, with two striking exceptions: vaccination was substantially lower among people with severe mental illnesses and learning disabilities. We observed substantial geographic variation in vaccination coverage between STPs. 17.6% (n=169,472) of people have received a second dose of the vaccine; at this stage of the vaccination campaign most received Pfizer-BioNTech, with only 6.8% receiving the AstraZeneca-Oxford vaccine.

Strengths and weaknesses
The key strengths of this study are the scale, detail and completeness of the underlying raw EHR data. The OpenSAFELY-TPP platform runs analyses across the full dataset of all raw, pseudonymised, single-event-level clinical events for all 23.4 million patients at all 2,545 GP practices in England using TPP software; this includes data on all tests, treatments, diagnostic events, and other salient clinical and demographic information. OpenSAFELY-TPP also provides data in near-real time, providing unprecedented opportunities for audit and feedback to rapidly identify and resolve concerns around health service activity and clinical outcomes: the delay from entry of a clinical event into the EHR to it appearing in the OpenSAFELY-TPP platform varies from two to nine days. This is substantially faster than any other source of comprehensive GP data; and is additionally linked to other sources of data including hospitalisations data from SUS, ITU data from ICNARC, and COVID test data from SGSS, and death data from ONS, supporting timely monitoring of vaccine coverage, safety, and effectiveness as well as other covid-related analyses [14].

We recognise some limitations to our analysis. Our population, though extremely large, may not be fully representative: there is some geographic clustering in choice of electronic health record system, and only 17% of general practices in London use TPP software. Solely for our analysis of geographic variation we include only 60% of STPs as those with less than 10% population coverage were excluded. Our ascertainment of vaccination status relies on the electronic message into the primary care record; while our numbers are consistent with national figures, we are exploring methods to also cross-validate this against other sources of person-level vaccination data, broken down by vaccination site type. Primary care records in England are detailed and longitudinal, but can be incomplete for data on some patient characteristics: for example ethnicity was missing for 28.1% of people over the age of 80, and IMD was unknown for 1.8% of people over 80. There is currently no well-validated person-level data to identify individuals currently resident in a care home: this is a limitation for all UK healthcare database studies covering a large population. Our method for
identifying care home residents was specific rather than sensitive, and will lead to under-ascertainment. We are launching a programme of work, in collaboration with the UK health data science community, to describe and validate the best methods for identifying current care home residents, in order to produce a better understanding of their health outcomes.

**Findings in Context**

The UK has already administered 6.65 vaccines per 100 people, one of the fastest vaccination programmes in the world [15]. NHS England and Public Health England (PHE) release reports on vaccine delivery using data extracted from the NIMS: NHS England reported that as of January 13th, 2,494,371 first dose vaccinations have been administered [16] which is in line with our finding of 961,580 people being vaccinated in OpenSAFELY-TPP data covering 40% of the population. Our findings on variation in vaccination between STPs are consistent with the NHS England weekly report on January 21st which contained raw counts of vaccination between STPs totalling 3.98 million doses with a range of 27,764 to 271,536 doses [17]. PHE reported that 34.6% of the over-80 cohort had been vaccinated with a first dose by the week ending January 10th, which is also consistent with our finding of 41.1% of this priority group receiving a vaccination by January 13th [18]. It is reasonable to expect marginal differences in the proportion of each risk group vaccinated between different summary reports from different analytic teams due to minor differences in the speeds of data flow, and in the ascertainment of denominators.

To our knowledge this paper is the first study to describe in detail the demographic and clinical features of those who have been vaccinated by the NHS England COVID-19 vaccination campaign; and the first to report variation in vaccination by ethnicity and clinical characteristics. This is because OpenSAFELY-TPP can provide detailed information about the demographics and clinical conditions of those vaccinated which is not available within NIMS. Our finding of discrepancies between ethnic groups is concerning: it requires action, and further investigation; possible drivers include systematic barriers to healthcare access, and vaccine hesitancy amongst certain groups [19,20,21,22–24,25]; it may also only arise in the very earliest stages of this new vaccination programme.

**Policy Implications and Interpretation**

The reasons underpinning variation in COVID-19 vaccination coverage are not yet understood, and information presented here should not be misinterpreted as a criticism of the rapidly established NHS vaccination campaign. Further research is needed to understand and address the observed lower coverage among people from more deprived areas, and the striking disparity between ethnic groups.

It is reassuring to see that those with a previous history of various medical problems, and common mental health problems, are being vaccinated at the same rate as other patients: in particular it is reassuring to see no evidence that the vaccine programme is currently missing those with serious physical health problems who are at highest risk of death from COVID-19. The lower vaccination rates among people with severe mental illness, and with learning disabilities, are concerning; this may reflect challenges around access, including for those currently living in institutional settings; and may therefore be resolved by wider availability of the AstraZeneca-Oxford vaccine, which does not present the same logistic challenges around extremely low temperature supply chains as Pfizer-BioNTech.
We are delivering regular data reports to key stakeholders in the NHS and UK government to assist them in monitoring and targeting vaccine initiatives. We will produce data updates at www.opensafely.org/covidvaccineuptake, including a machine readable version of the report. Working closely with EHR and associated software providers we plan to present actionable and contextualised data insights directly back to local areas and individual practices to help them target and expedite delivery of COVID-19 vaccines. Vaccination data by STP is available from the NHS England website [16]; we are happy to assist STPs with additional local data on request. Variation in vaccination coverage, by and within regions, will have many complex drivers: in our view this data should be interpreted cautiously.

We note that all findings in this paper are from the first few preliminary weeks of a major national vaccination programme. Very substantial changes in coverage among different groups are to be expected over the coming months.

**Summary**

The NHS in England has rapidly deployed a mass vaccination campaign. Targeted activity may be needed to address lower vaccination rates observed among certain key groups: ethnic minorities, people living in areas of higher deprivation, and those with severe mental illness or learning disabilities. Live data monitoring is likely to help support those on the front line making complex operational decisions around vaccine roll-out.
Administrative

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Conflicts of Interest

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare the following: over the past five years BG has received research funding from the Laura and John Arnold Foundation, the NHS National Institute for Health Research (NIHR), the NIHR School of Primary Care Research, the NIHR Oxford Biomedical Research Centre, the Mohn-Westlake Foundation, NIHR Applied Research Collaboration Oxford and Thames Valley, the Wellcome Trust, the Good Thinking Foundation, Health Data Research UK (HDRUK), the Health Foundation, and the World Health Organisation; he also receives personal income from speaking and writing for lay audiences on the misuse of science. KB holds a Sir Henry Dale fellowship jointly funded by Wellcome and the Royal Society (107731/Z/15/Z). HIM is funded by the NIHR Health Protection Research Unit in Immunisation, a partnership between Public Health England and London School of Hygiene & Tropical Medicine. AYSW holds a fellowship from the British Heart Foundation. EJW holds grants from MRC. RG holds grants from NIHR and MRC. RM holds a Sir Henry Wellcome Fellowship funded by the Wellcome Trust (201375/Z/16/Z). HF holds a UKRI fellowship. IJD has received unrestricted research grants and holds shares in GlaxoSmithKline (GSK).

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Information governance and ethical approval

NHS England is the data controller; TPP is the data processor; and the key researchers on OpenSAFELY are acting on behalf of NHS England. This implementation of OpenSAFELY is hosted within the TPP environment which is accredited to the ISO 27001 information security standard and is NHS IG Toolkit compliant,[26,27] patient data has been pseudonymised for analysis and linkage using industry standard cryptographic hashing techniques; all pseudonymised datasets transmitted for linkage onto OpenSAFELY are encrypted; access to the platform is via a virtual private network (VPN) connection, restricted to a small group of researchers; the researchers hold contracts with NHS England and only access the platform to initiate database queries and statistical models; all database activity is logged; only aggregate statistical outputs leave the platform environment following best practice for anonymisation of results such as statistical disclosure control for low cell counts.[28] The OpenSAFELY research platform adheres to the obligations of the UK General Data Protection Regulation (GDPR) and the Data Protection Act 2018. In March 2020, the Secretary of State for Health and Social Care used powers under the UK Health Service (Control of Patient Information) Regulations 2002 (COPI) to require organisations to process confidential patient information for the purposes of protecting public health, providing healthcare services to the public and monitoring and managing the COVID-19 outbreak and incidents of exposure; this sets aside the requirement for patient consent.[29] Taken together, these provide the legal bases to link patient datasets on the OpenSAFELY platform. GP practices, from which the primary care data are obtained, are required to share relevant health information to support the public health response to the pandemic, and have been informed of the OpenSAFELY analytics platform. This study was approved by the Health Research Authority (REC reference 20/LO/0651) and by the LSHTM Ethics Board (reference 21863).

Guarantor

BG/LS are guarantors.
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Appendix 1

**COVID vaccinations among 80+ population by ‘chemotherapy or radiotherapy - ever’**

![Graph showing COVID vaccinations among 80+ population by chemotherapy or radiotherapy - ever.](image)

**COVID vaccinations among 80+ population by haematological cancer’**

![Graph showing COVID vaccinations among 80+ population by haematological cancer.](image)
COVID vaccinations among 80+ population by ‘SSRIs in the past year (but no known ‘psychosis, schizophrenia, bipolar, intellectual disability or dementia)