1

Trends in risks of severe events and lengths of stay for COVID-

19 hospitalisations in England over the pre-vaccination era:

results from the Public Health England SARI-Watch

surveillance scheme

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Abstract

Background: Trends in hospitalised case-fatality risk (HFR), risk of intensive care unit (ICU) admission and lengths of stay for patients hospitalised for COVID-19 in England over the prevaccination era are unknown.

Methods: Data on hospital and ICU admissions with COVID-19 at 31 NHS trusts in England were collected by Public Health England's Severe Acute Respiratory Infections surveillance system and linked to death information. We applied parametric multi-state mixture models, accounting for censored outcomes and regressing risks and times between events on month of admission, geography, and baseline characteristics.

Findings: 20,785 adults were admitted with COVID-19 in 2020. Between March and June/July/August estimated HFR reduced from 31.9% (95% confidence interval 30.3-33.5%) to 10.9% (9.4-12.7%), then rose steadily from 21.6% (18.4-25.5%) in September to 25.7% (23.0-29.2%) in December, with steeper increases among older patients, those with multi-morbidity and outside London/South of England. ICU admission risk reduced from 13.9% (12.8-15.2%) in March to 6.2% (5.3-7.1%) in May, rising to a high of 14.2% (11.1-17.2%) in September.

Median length of stay in non-critical care increased during 2020, from 6.6 to 12.3 days for those dying, and from 6.1 to 9.3 days for those discharged.

Interpretation: Initial improvements in patient outcomes, corresponding to developments in clinical practice, were not sustained throughout 2020, with HFR in December approaching the levels seen at the start of the pandemic, whilst median hospital stays have lengthened. The role of increased transmission, new variants, case-mix and hospital pressures in increasing COVID-19 severity requires urgent further investigation.

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Introduction

COVID-19 patients admitted to hospital in England experience different possible pathways to a final outcome of either discharge or death, including admission to critical care (an intensive care unit (ICU) or high dependency unit (HDU)), a step-down from critical care to an acute ward, and transfers between hospitals. Knowledge of the risk of each pathway, the times taken (lengths of stay) to reach final outcomes and, particularly, how these change over time, are crucial to: (i) evaluate the effect of clinical and public health strategies on reducing disease burden (e.g. by reconstructing the evolution of the pandemic); and (ii) inform future policies, through medium- and long-term predictions of hospital demand [1,2]. Preliminary evidence exists for changes in mortality among critically ill patients with COVID-19 admitted to ICU/HDU in England during the first wave of the pandemic, with factors including age, sex, ethnicity and comorbidity associated with differing severity for hospitalised individuals [3–6]. However, little is known about how both risks of outcomes, and lengths of stay for all hospitalised patients have changed over time, particularly after the first pandemic wave up to the present vaccination era.

In March 2020, Public Health England (PHE) swiftly reconfigured existing influenza hospital surveillance to collect detailed individual-level data on COVID-19 patients, through the Severe Acute Respiratory Infections in England (SARI-Watch) surveillance system [7]. These data, which include all dates of movement between levels of care and outcomes and patient characteristics, allow estimation of the progression of COVID-19 patients through each hospital pathway. In this study we focus on how risks of each event and lengths of stay have varied over the months of the pandemic. In particular, we estimate changes in the hospital-fatality risk (HFR), averaged over the different pathways through hospital. Using parametric mixture multi-state models, we correctly account for both the competing risks of each pathway and missing outcome information (censoring) [8–10].

Methods

Study design and setting

Public Health England's (PHE's) Severe Acute Respiratory Infections in England (SARI-Watch) surveillance system, previously known as the COVID-19 Hospitalisations in England Surveillance System (CHESS), is a mandatory reporting system for all ICU/HDU admissions with COVID-19 at National Health Service (NHS) trusts in England [7]. A subset of 'sentinel' NHS trusts report information on the wider range of all hospital admissions.

Participants

All adults aged 15+ admitted to 31 SARI-Watch sentinel NHS trusts between 15th March and 31st December 2020 with laboratory confirmed SARS-CoV-2 infection. Nosocomial cases of COVID-19 were excluded. Follow-up to death (COVID-19 associated or other cause) was extended until 11th January 2021, via linkage.

Variables

Variables collected in SARI-Watch include dates of hospital and critical care admission, date and type of outcome and baseline characteristics, specifically: age group, sex, region of residence (London, South, Midlands and East, and North of England), self-reported ethnicity and number of comorbidities. Due to small sample sizes, covariates were grouped where appropriate. Month groupings were: March, April, May, June/July/August, September, October, November and December; age groups were: 15-44, 45-64, 65-74, and 75+; region groupings were: London/South of England, Midlands and East of England, and North of England; ethnicity groupings were: Asian, Black, Mixed/Other and White; and comorbidity burden was grouped as: 0, 1, 2, and 3+ comorbidities. Comorbidity included pre-existing serious medical conditions such as: coronary heart disease, BMI≥30, diabetes, immunosuppression due to treatment or disease, renal disease, liver disease, neurological disorders, respiratory disease (excluding asthma), and asthma requiring medication.

Data sources and outcomes

SARI-Watch data are submitted to PHE via a secure online reporting tool, with data reporters able to update records with subsequent patient outcome information. Linkage to PHE's data on deaths among people with COVID-19 [11] was undertaken to obtain complete information on date and cause of COVID-19-related death. Self-declared ethnicity was obtained through linkage to the NHS Hospital Episodes Statistics database (HES) [12]. Linkage was undertaken for data up to 11th January 2021. Further details concerning these linkages are provided in the Appendix.

Bias

We obtained complete information on mortality and our statistical methodology was specifically designed to account for censored outcomes. The 31 sentinel trusts were verified to have consistent reporting of both critical and non-critical care patients over time and compared against aggregate admissions data for COVID-19 (see Appendix for list of trusts). Sentinel NHS trusts were originally recruited by PHE using regional and trust representation sampling, during the COVID-19 pandemic trusts chose whether to continue sentinel reporting leading to certain regions being over-represented, this may have introduced bias for which we could not account.

Statistical methods

We used a multi-state competing risks mixture model with four states: non-critical care, critical care (ICU), discharge and death, and two sub-models: events following hospital admission and events following critical care (ICU) admission. The design of this multi-state model is shown in Figure 1 and details of the model and model parameters are provided in the Appendix. Briefly, the model defines the probability that each competing event will occur next, and the distribution of the time to each event if that event occurs [13]. The probabilities of competing events were related to covariates through multinomial logistic regression, and the times to events were related to covariates through accelerated failure time models. The covariates considered included month of admission, age group, gender, ethnicity, region and number of comorbidities, as detailed in the Appendix. Time-to-event distributions and covariates on model parameters were chosen through critical assessment of goodness of fit (by comparison to non-parametric Aalen-Johansen cumulative incidence curves) and Akaike's information criterion (AIC).

The two sub-models shown in Figure 1 are a simplification of the patient pathway, to account for poorly completed information on unit type and critical care discharge dates. Critical care (ICU and HDU) admissions were combined into a single "ICU" state and additional hospital stays following ICU discharge were combined with the ICU state. Date of hospital admission, date of ICU admission for those admitted to ICU, and date and type of final outcome (discharge or death) were well completed.

Censoring

Overall, 13.7% of hospital admissions (2,843/20,785) and 17.7% of critical care admissions (392/2,213) had unknown final outcomes. These outcomes may be missing either because they were not reported despite having occurred (which we term "truly" missing), or because they had not occurred by the end of the period covered by the data (termed "right-censoring"). For earlier months, missing outcomes are more likely to be truly missing, whereas in the most recent months, a greater proportion of missing outcomes are likely to represent patients who remain in hospital care.

Among those with unknown outcome, a last known status was reported as either: 'still in hospital/still in ICU' at the date of data extraction, transferred on a particular date, or unknown. Patients 'still in hospital/still in ICU' were censored at the date of data extraction, or at 60 days if they were reported as still in non-critical care beyond 60 days, or at 90 days if they were reported as still in critical care beyond 90 days (Figure 2). This approach was a compromise between excluding these records from the analysis and censoring at the date of data extraction, which would allow for unrealistically long hospital stays of several months after admission. The 60/90-day windows included 99% of observed final outcomes, and 90-day in-hospital outcomes are also used in other studies of critical care [3]. Transferred patients with unknown outcome were censored at

the date of transfer, patients with unknown status and unknown outcome were censored at the date of their last observed event.

Model implementation

Models were implemented using the flexsurv (version 2.0) package [14] in R (version 4.0.3) [15]. HFR, averaged over admissions with and without ICU, was estimated by combining the two submodels. We report 95% confidence intervals representing uncertainty in estimates, and for lengths of stay we additionally report interquartile ranges representing heterogeneity within the population. Tables of estimated quantities, odds ratios and expected time ratios are provided in the Appendix.

Results

Participant characteristics

A total of 20,785 patients were admitted to a sentinel NHS trust between 15th March and 31st December 2020. The flowchart in Figure 2 shows the various pathways taken by patients and the aggregated number of observed transitions between each state.

Table 1 presents baseline characteristics by month of admission. Among those admitted to a sentinel NHS trust in March, 60% (2,037/3,391) were male, this proportion decreased to 50% (1,117/2,197) in May and remained between 50-55% for subsequent months. The age distribution of patients admitted to hospital fluctuated from month to month, with around 60% aged over 65 and 40% aged under 65. Meanwhile, the proportion of individuals of White ethnicity increased, from 63% (2,148/3,391) in March to 80% (1,768/2,200) in December, with a corresponding reduction in the proportion of patients of Asian, Black and Mixed/Other ethnicity. Patients admitted towards the end of the study period had fewer comorbidities; 44% (1,507/3,391) of patients admitted in March had three or more comorbidities, compared to 33% (721/2,200) of those admitted in December. The proportion with zero comorbidities rose from 18% (594/3,391) in March to 28% (623/2,200) in December. Differing regional trends were observed in hospital admissions; during March and April over half of admissions (60% and 54%, respectively) occurred in London and the South of England, whereas in September and October most hospital admissions (60% and 59%, respectively) occurred in the North of England.

Critical care admissions

Figure 3 shows the proportion of hospital admissions admitted to ICU over time by age and sex. Trends for non-critical care admissions were similar across all age groups and both sexes. A greater proportion of men compared to women and middle-aged (aged 45-75) patients compared to younger (aged 15-45) and older (aged 75+) patients were admitted to critical care.

Outcome probabilities

Estimated outcome probabilities following hospital admission are shown in Figure 4.

Probability of ICU admission following hospital admission dramatically decreased between March and May, from 13.9% (95% confidence interval 12.8-15.2%) to 6.2% (5.3-7.1%); subsequently rising to a peak of 14.2% (11.1-17.2%) in September, followed by a steady fall to 9.6% (8.6-10.9%) in December. These trends were similar across all subgroups.

Probability of death outside of critical care declined from 25.3% (23.8-26.8%) in March to 9.4% (7.9-11.1%) in June/July/August (OR 0.8, 0.6-1.1), followed by a resurgence to 23.1% (20.4-26%) in December (OR 1.3, 1.1-1.6). Over the study period, patients aged 65-74 and 75+ had significantly greater odds of death outside of critical care compared to patients aged 15-45 (OR 8.2, 3-8-18 and OR 71.1, 32.7-154.4, respectively). Patients with multiple comorbidities were similarly at greater risk of death outside of critical care (OR 2.3, 1.5-3.5 for 2 comorbidities and OR 5.2, 3.6-7.5 for 3+ comorbidities) compared to those with no comorbidities (Supplementary table 8).

Figure 5 shows estimated probability of death among patients admitted to critical care. This fell from 47.4% (42.5-51.7%) in March to 24.1% (16.1-35.1%) in June/July/August, increased to 40.2% (34.1-46.6%) in October and fell again to 26.8% (20.2-34.2%) in December. Whilst confidence intervals are wide in smaller groups, this oscillating trend was estimated across most subgroups.

Hospitalised case-fatality risk

Estimated hospitalised case-fatality risk (HFR), averaged across ICU and non-ICU admissions, is shown in Figure 6. Between March and June/July/August HFR reduced from 31.9% (30.3-33.5%) to 10.9% (9.4-12.7%); this was followed by an increase to 21.6% (18.4-25.5%) in September and steady rise to 25.7% (23.0-29.2%) for patients admitted in December. Whilst the initial fall in HFR was estimated across all subgroups, the increase to December was estimated particularly in the oldest age group (75+) and those with three or more comorbidities, with estimated HFRs of 42.6% (38.3-46.8%) and 34.5% (29.9-38.9%) for admissions in the final month of 2020, respectively.

In December, HFR was estimated to be higher in the North of England, at 28.6% (23.3-34.8%), and Midlands and East of England, at 27% (22.9-31.6%), compared to London and the South of England at 19.3% (16.1-23.3%). HFR for people of White ethnicity was higher during December, at 27.4% (24.3-30.8%), compared to 13% (9-19.3%) and 7.3% (3.3-18.6%) for people of Asian and Mixed/Other ethnicity, respectively. Whilst HFR for people of Black ethnicity was estimated to be lower than those of White ethnicity during March to June/July/August, confidence intervals were wider in December and overlapped the HFR for White ethnicity.

Length of stay

Estimated median times from hospital admission to next event are shown in Figure 7. Time to ICU admission remained low throughout the period, with a median of between 0.8 and 1.3 days after hospital admission (Figure 7A). Median length of stay in hospital prior to death in non-critical care increased from 6.6 days (6.2-7.1 days) in March to 12.3 days (10.9-14.0 days) in December, with a similar trend across all subgroups. Median lengths of stay in non-critical care prior to discharge initially fell from 6.1 days (5.7-6.5 days) for admissions during March to 4.1 days (3.8-4.5 days) in June/July/August, before lengthening to 9.3 days (8.5-10.3 days) in December. Heterogeneity between lengths of stay prior to discharge or death increased over time, with wider inter-quartile ranges estimated in more recent months.

Estimated length of stay in non-critical care prior to discharge was longest among older patients, with a median of 17.8 days (16.2-19.7 days) for patients aged 75+ (expected time ratio, ETR compared to 15-45: 3.7, 3.5-4) admitted in December (Figure 7C). Length of stay in non-critical care prior to discharge was also longer in the North (ETR compared to London/South 1.7, 1.6-1.9) compared to elsewhere in England; 13.8 days (12.3-15.6 days) in the North of England in December compared to 7.9 days (7.2-8.9 days) in London and the South of England and 9.9 days (9.0-11.1 days) in the Midlands and East of England (Figure 7D).

Figure 8 shows lengths of stay in ICU; as compared to non-critical care patients (Figure 7) patients admitted to critical care spent longer in hospital. Median length of stay in ICU prior to discharge initially reduced from 24.4 days (21.1-28.5 days) in March to 13.8 days (10.2-18.5 days) in June/July/August (ETR 0.6, 0.4-0.8), then increased to 38 days (29-48.9 days) in December (ETR 1.6, 1.2-2.1). Median length of stay in ICU prior to death showed less variability over time, ranging between 8.6 and 12.5 days.

Discussion

Principal findings

Since the start of the COVID-19 pandemic in England, risks of severe events and lengths of stay in hospital have varied by month of admission and according to baseline characteristics. The hospitalised case-fatality risk fell during the first 'wave' of the pandemic (March to June/July/August), although a resurgence was estimated across all subgroups up to December 2020, particularly among older patients, those presenting with multiple comorbidities, those of White ethnicity (unadjusted for age), and regions outside London and the South of England. Meanwhile, lengths of stay in hospital for patients admitted with COVID-19 have tended to increase since the start of the pandemic.

Temporal variations in patient outcomes and lengths of stay are likely to be influenced by a range of factors, including changes in patient characteristics and in clinical practice. Despite accounting

for changes in patient characteristics over time, these covariates did not fully explain the decline and subsequent increase in severity for hospitalised COVID-19 patients, with trends persisting.

Comparison with other studies

Our estimates for critical care patients support the findings of the Intensive Care National Audit & Research Centre which reported a reduction in critical care mortality between March and June 2020, followed by an increase in mortality during the autumn and subsequent slow decline [3].

Considering all hospitalised patients, the International Severe Acute Respiratory and emerging Infections Consortium (ISARIC) estimated a reduction in in-hospital mortality among 208 hospitals in England, Scotland, and Wales, from 30-35% in March and early April to 10-15% in late July and August [6]. Meanwhile estimates of in-hospital mortality from the HES dataset, adjusted for age, sex, comorbidity, deprivation and date, showed a decline between early March and late May from 52.2% to 16.8% [16].

Our study, whilst limited to a selected group of hospitals, provides further evidence of this decline in hospitalised mortality during the first wave of COVID-19 in England. By accounting for competing risks, we additionally estimated trends in risks of ICU admission and hospital discharge, as well as lengths of stay for both critical and non-critical care patients. A key strength of our work is the longer follow-up period, which allowed for previously unexplored trends throughout 2020, in particular in autumn and winter, to be estimated.

Compared to the ISARIC study, we estimated a lower risk of ICU admission during March and April (17% vs 10 to 14%) [6]. Hospitals in London were the first to experience high numbers of critical care admissions during the first wave, so the fact that London sites were under-represented in the list of reporters to our study likely contributed to the reduced overall severity of infection in our estimates during these months compared to this study.

Several studies have shown association between increased severity due to COVID-19 and baseline covariates [3,5,6,16]. In common with these studies, we estimated increased risk of mortality for older patients and those with multiple comorbidities. These studies have also linked increased deprivation, and Asian, Black or Mixed/Other ethnicity compared to White ethnicity to increased severity. Full postcode information was unavailable and we were therefore unable to account for deprivation in our study. We estimated lower HFR for people of Asian, Black or Mixed/Other ethnicities compared to White ethnicity, this may be due to a differing age profile for these populations. Supplementary Figure 3 presents HFR by three covariates: month of admission, age group and ethnicity, showing that after controlling for age, HFR was similar for people of Asian, Black and White ethnicities, although with wider confidence intervals in groups of smaller size.

Strengths and limitations of the study

By linking with PHE's mortality data we were able to identify all deaths due to COVID-19 occurring in the population, improving the completeness of the death information and thereby reducing uncertainty in our mortality estimates.

Another strength of this work is the statistical software we applied to surveillance data, allowing for robust estimates of outcome probability and lengths of stay to be obtained. Whilst we did not explicitly model seasonality, instead using a categorical month covariate, cyclic regression models or other smoothed functions of time could be used in future work to investigate seasonal variation in COVID-19 mortality rates.

Vaccination for COVID-19 in England began in mid-December 2020, with around 1.2 million people receiving their first dose by the end of December [17]. Our estimates cover the entire prevaccination period and therefore provide a comprehensive assessment of hospital severity before the effects of vaccination could be felt.

A limitation of the sentinel reporting was smaller group sizes compared to other studies [4,16], this led to increased uncertainty in our estimates, particularly among BAME patient groups, and limited analyses to only two covariates for the most part (month of admission plus one demographic factor). This limited the extent to which interactions between covariates could be explored, although it is likely that a high degree of correlation exists between certain covariates.

Conclusions and policy implications

Improved patient management, along with containment of COVID-19, is likely to have contributed to the estimated reduction in mortality during the first wave of infection in England [18]. From March onwards, hospital wards were re-configured to prepare for a rapidly increasing number of severe cases [19], nevertheless, several London-based hospitals entered 'surge', with availability of staff and ventilator units limiting the number of critical care beds [20]. At this time, there may have been prioritisation of ICU treatments to those most likely to benefit from invasive treatments, which may be reflected in our estimated improvements in patient outcomes. Concurrent national lockdown restrictions were effective in limiting transmission of COVID-19 in the community, slowing the influx of new patients from April onwards [21]. Use of treatments, such as Dexamethasone, and therapies such as prone positioning also improved outcomes for patients in non-critical care wards [22,23].

The estimated increase in mortality after the summer months may reflect a combination of multiple factors: increased transmission after easing of national restrictions; regional outbreaks [24]; changes in case-mix with a greater proportion of older, clinically vulnerable individuals observed being admitted to hospital [25]; seasonality; the emergence of new variants of concern (still a matter of debate and research [26]); and overloading of hospitals in hotspots and nationwide

towards the end of the year [27]. Changes in critical care bed occupancy were worryingly correlated with estimated changes in mortality (Supplementary Figure 4), for example, although this crude comparison may hide a multitude of interlinked factors.

The concerning trends in hospitalised case-fatality risk and the relationship between increased transmission, appearance of new variants, hospital pressure, and mortality merits further urgent investigation. Changes in outcomes of patients admitted to hospital should continue to be closely monitored. Our results provide an invaluable baseline for future evaluation of the effect of vaccination on mortality and have been shared with the UK Government's Scientific Pandemic Influenza Group on Modelling (SPI-M) and Scientific Advisory Group for Emergencies (SAGE) [28,29].

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Patient and public involvement

This study was a retrospective cohort analysis. The research question, design and data collection were motivated by the response to an urgent public health emergency. The surveillance data were collected by Public Health England with permissions granted under Regulation 3 of The Health Service (Control of Patient Information) Regulations 2002, and without explicit patient permission under Section 251 of the NHS Act 2006. Although patients were not directly involved in the study design, the experiences of clinicians and public health officials interacting with patients informed the design of the data collection.

Data sharing: Requests to access non-publicly available data are handled by the PHE Office for Data Release (ODR). (https://www.gov.uk/government/publications/accessing-public-health-england-data/about-the-phe-odr-and-accessing-data)

Dissemination to participants and related patient and public communities: PHE and the MRC Biostatistics Unit have public facing websites and Twitter accounts @PHE_uk and @MRC_BSU. PHE and the MRC Biostatistics Unit engage with print and internet press, television, radio, news, and documentary programme makers.

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Ethics approval: SARI-Watch is a mandatory surveillance system approved by the Department of Health and Social Care. Data were collected with permissions granted under Regulation 3 of The Health Service (Control of Patient Information) Regulations 2002, and without explicit patient permission under Section 251 of the NHS Act 2006.

Transparency statement: The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Authors' contributions: All authors conceived the research study. PK and AP drafted the manuscript. CJ developed the flexsurv package and advised on methods. PK carried out the multistate model analyses. SE co-ordinated the linkage to ONS and HES and formatted the dataset. The dataset was verified by PK and CJ. All authors provided critical review of the manuscript prior to submission. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. PK is the guarantor.

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Tables

Table 1: Baseline characteristics of patients with COVID-19 admitted to sentinel NHS trusts during 15th March to 31st December 2020, by month and covariate

Group	Mar	Apr	May	Jun/Jul/ Aug	Sep	Oct	Nov	Dec
All	3391	6923	2197	1304	450	1861	2459	2200
	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)
Sex	(100,0)	(12272)	(10070)	(100,0)	(10070)	(10070)	(10070)	(100,0)
Female	1354	2969	1080	619	203	851	1168	1045
	(39.9%)	(42.9%)	(49.2%)	(47.5%)	(45.1%)	(45.7%)	(47.5%)	(47.5%)
Male	2037	3954	1117	685	247	1010	1291	1155
	(60.1%)	(57.1%)	(50.8%)	(52.5%)	(54.9%)	(54.3%)	(52.5%)	(52.5%)
Age group								
15-44	414 (12.2%)	718 (10.4%)	296 (13.5%)	229 (17.6%)	90 (20%)	220 (11.8%)	337 (13.7%)	339 (15.4%)
45-64	1023	1973	524	382	132	488	599	619
	(30.2%)	(28.5%)	(23.9%)	(29.3%)	(29.3%)	(26.2%)	(24.4%)	(28.1%)
65-74	610	1237	363	240	75	403	482	361
	(18%)	(17.9%)	(16.5%)	(18.4%)	(16.7%)	(21.7%)	(19.6%)	(16.4%)
75+	1344 (39.6%)	2995 (43.3%)	1014 (46.2%)	453 (34.7%)	153 (34%)	750 (40.3%)	1041 (42.3%)	881 (40%)
Region of residence								
London/South of	2020	3712	783	457	55	191	462	635
England	(59.6%)	(53.6%)	(35.6%)	(35%)	(12.2%)	(10.3%)	(18.8%)	(28.9%)
Midlands and East of England	911	1914	731	436	127	570	1039	1072
	(26.9%)	(27.6%)	(33.3%)	(33.4%)	(28.2%)	(30.6%)	(42.3%)	(48.7%)
North of England	460	1297	683	411	268	1100	958	493
	(13.6%)	(18.7%)	(31.1%)	(31.5%)	(59.6%)	(59.1%)	(39%)	(22.4%)
Ethnicity								
Asian	424 (12.5%)	848 (12.2%)	184 (8.4%)	158 (12.1%)	72 (16%)	152 (8.2%)	189 (7.7%)	184 (8.4%)
Black	520	653	124	83	11	25	28	55
	(15.3%)	(9.4%)	(5.6%)	(6.4%)	(2.4%)	(1.3%)	(1.1%)	(2.5%)
Mixed/Other	163	320	81	49	15	27	53	68
	(4.8%)	(4.6%)	(3.7%)	(3.8%)	(3.3%)	(1.5%)	(2.2%)	(3.1%)
White	2148	4799	1730	975	338	1573	2106	1768
	(63.3%)	(69.3%)	(78.7%)	(74.8%)	(75.1%)	(84.5%)	(85.6%)	(80.4%)
Unreported*	136 (4%)	303 (4.4%)	78 (3.6%)	39 (3%)	14 (3.1%)	84 (4.5%)	83 (3.4%)	125 (5.7%)
Number of comorbidities								
0	594	1402	383	291	121	416	603	623
	(17.5%)	(20.3%)	(17.4%)	(22.3%)	(26.9%)	(22.4%)	(24.5%)	(28.3%)
1	629	1246	406	270	114	347	481	459
	(18.5%)	(18%)	(18.5%)	(20.7%)	(25.3%)	(18.6%)	(19.6%)	(20.9%)
2	661 (19.5%)	1284 (18.5%)	410 (18.7%)	215 (16.5%)	80 (17.8%)	368 (19.8%)	483 (19.6%)	397 (18%)
3+	1507 (44.4%)	2991 (43.2%)	998 (45.4%)	528 (40.5%)	135 (30%)	730 (39.2%)	892 (36.3%)	721 (32.8%)

^{*} Unreported ethnicity excluded from multi-state mixture model.

Figures

Figure 1: Multi-state model for COVID-19 hospital admissions. Arrows indicate transitions between states in each of the 'From Hospital' and 'From ICU' sub-models.

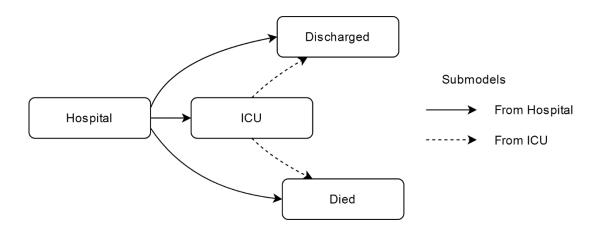


Figure 2: Flow diagram showing pathways through multi-state model, with observed number and proportion of individuals in and moving between each state. Dotted lines indicate right-censoring, i.e. those with unknown or not yet experienced outcomes. Dashed lines indicate right-censoring for individuals reported as "still in hospital" for >60 days or "still in ICU" for >90 days.

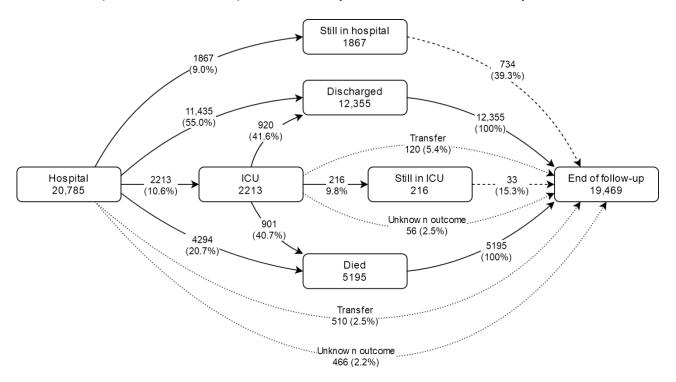


Figure 3: Proportion of COVID-19 hospital admissions by ICU admission status, gender and age group.

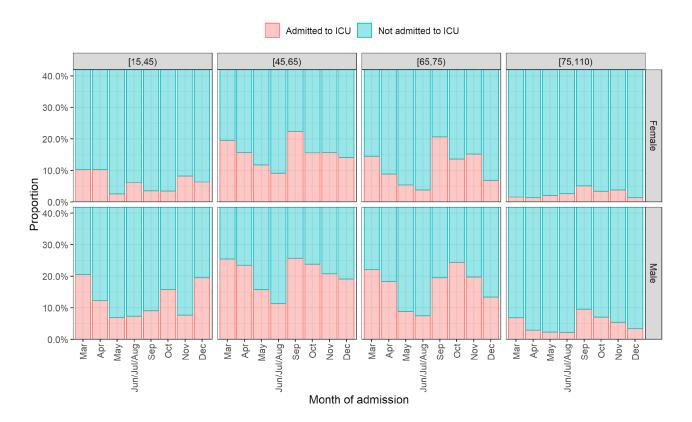


Figure 4: Probability of next event following hospital admission ('From Hospital' sub-model), by month of admission (panel A), sex (panel B), age group (panel C), region of residence (panel D), ethnicity (panel E), and number of comorbidities (panel F). Error bars are 95% confidence intervals to represent uncertainty in the estimated probability.

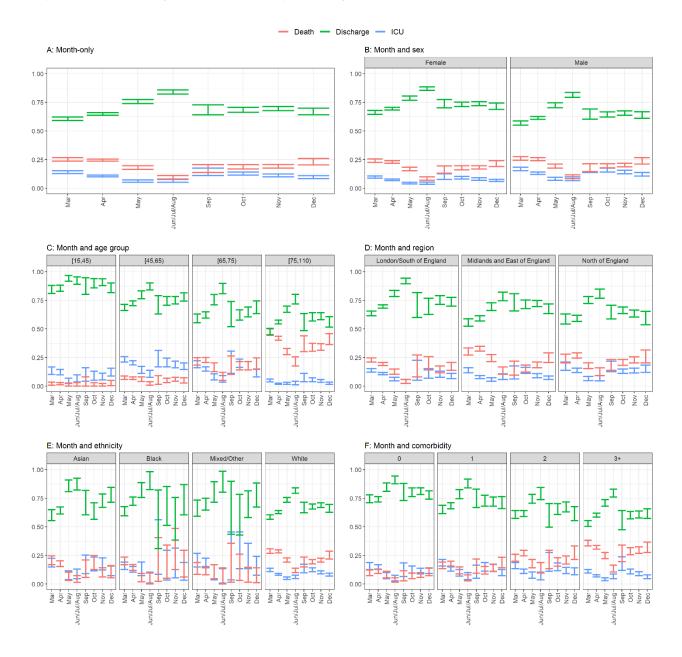


Figure 5: Probability of death following ICU admission ('From ICU' sub-model), by month of admission (panel A), sex (panel B), age group (panel C), region of residence (panel D), ethnicity (panel E), and number of comorbidities (panel F). Error bars are 95% confidence intervals to represent uncertainty in the estimated probability.

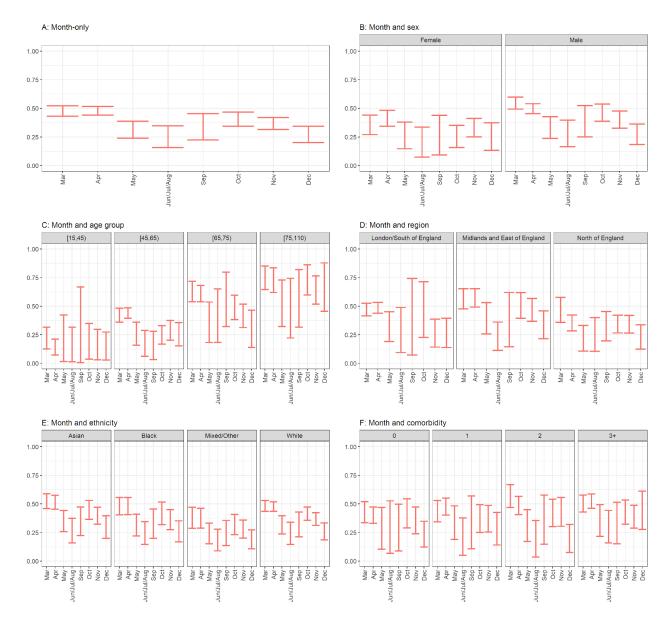


Figure 6: Estimated hospitalised case-fatality risk (HFR) averaged over ICU and non-ICU admission, by month of admission (panel A), sex (panel B), age group (panel C), region of residence (panel D), ethnicity (panel E), and number of comorbidities (panel F). Y-axis constrained to 0-0.6. Error bars are 95% confidence intervals to represent uncertainty in the estimated probability.

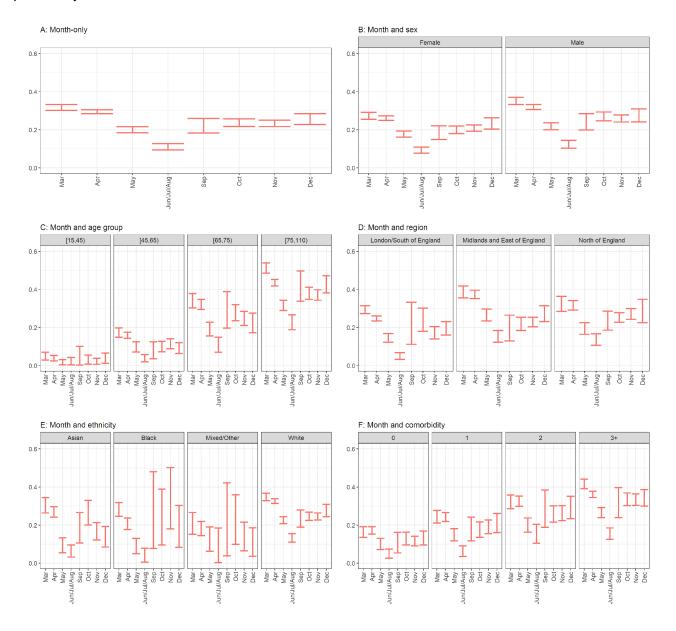


Figure 7: Estimated median time to event following hospital admission ('From Hospital' sub-model), by month of admission (panel A), sex (panel B), age group (panel C), region of residence (panel D), ethnicity (panel E), and number of comorbidities (panel F). Line ranges are interquartile ranges, representing variability in estimated times to event, error bars are 95% confidence intervals, representing uncertainty in the estimated median time.

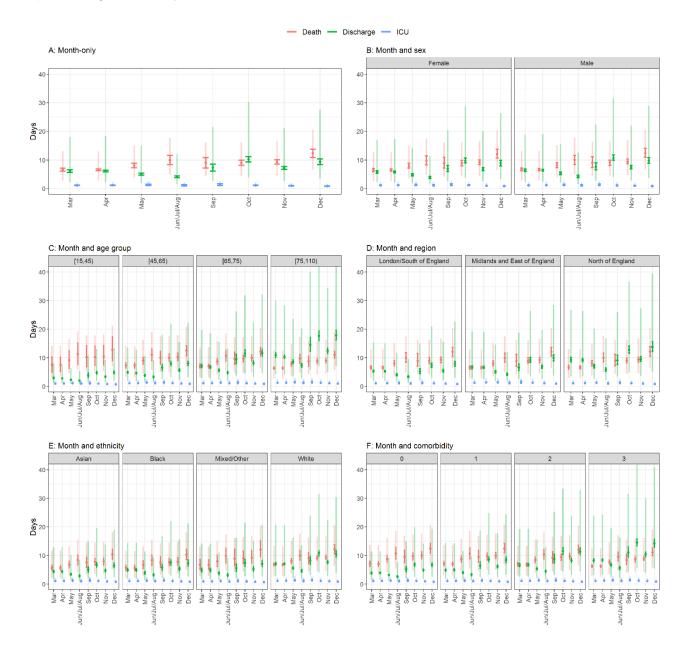
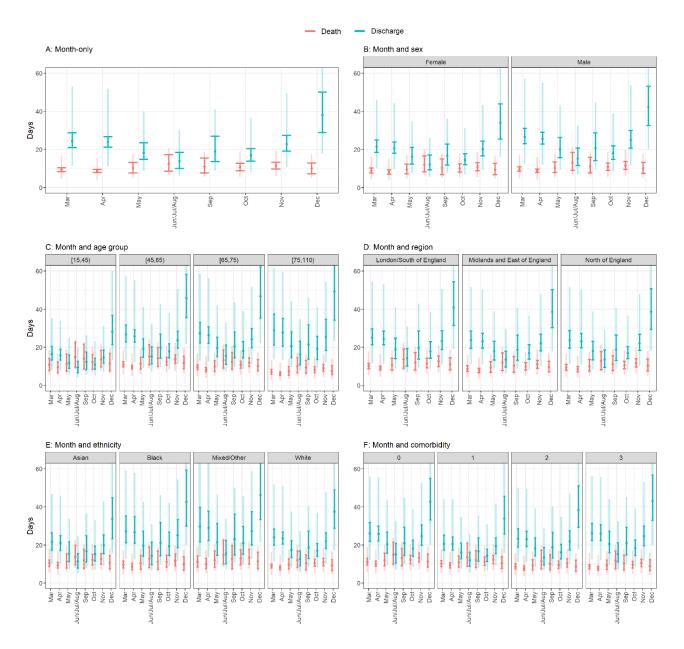


Figure 8: Estimated median time to event following ICU admission ('From ICU' sub-model), by month of admission (panel A), sex (panel B), age group (panel C), region of residence (panel D), ethnicity (panel E), and number of comorbidities (panel F). Line ranges are interquartile ranges, representing variability in estimated times to event, error bars are 95% confidence intervals, representing uncertainty in the estimated median time.



Appendix

Model description

We used a parametric semi-Markov multi-state model with four states. The model comprises two sub-models which represent competing risks of the next event 'from Hospital admission' and 'from ICU admission' (Figure 1).

In each of the sub-models an individual i in state r makes a transition to a state s with probability $\pi_{r,s}$. Denote $S_{r,s}$ the distribution of time from entering state r to moving to state s, given that this transition occurs (i.e. the conditional length of stay). A variety of parametric distributions are considered for this time.

This is a semi-Markov model, as the rates of transition to subsequent states depend on how long a person has spent in the current state, but not on any events before entering the current state.

Censoring of data

Transitions experienced by individual i are observed in the data as one of three types $\delta_{i,j}$:

- 1. exact transition time: $\{y_{i,j}, r_{i,j}, s_{i,j}, \delta_{i,j} = 1\}$ transition from state $r_{i,j}$ to state $s_{i,j}$ occurs at time $y_{i,j}$
- 2. right censoring: $\{y_{i,j}, r_{i,j}, s_{i,j}, \delta_{i,j} = 2\}$ follow-up ends while individual is in state $r_{i,j}$ at time $y_{i,j}$, the next state and time of transition are unknown
- 3. partially-known outcome: $\{y_{i,j}, r_{i,j}, s_{i,j}, \delta_{i,j} = 3\}$ it is known whether an individual went to ICU, but unknown if they are still in hospital at time $y_{i,j}$

Likelihood

Let $f_{r,s}(|\theta_{r,s})$ be the density of the parametric distribution for the time of transition from state r to state s, conditional on this being the transition that occurs. Then the likelihood contributions are:

$$\begin{split} \delta_{i,j} &= 1 \colon & l_{i,j} = \pi_{r_{i,j} s_{i,j}} f_{r_{i,j} s_{i,j}} (y_{i,j} | \theta_{r_{i,j} s_{i,j}}) \\ \delta_{i,j} &= 2 \colon & l_{i,j} = \sum_{s \in S_r} \pi_{r_{i,j} s} (1 - F_{r_{i,j} s} (y_{i,j} | \theta_{r_{i,j} s})) \\ \delta_{i,j} &= 3, s \neq \text{ Discharge:} & \text{as for } \delta_{i,j} &= 2 \\ \delta_{i,j} &= 3, s = \text{ Discharge:} & l_{i,j} &= \pi_{r_{i,j} s} \end{split}$$

Covariates

The flexsurv package in R is used to maximise this likelihood for the SARI-Watch dataset. Multinomial logistic regression is used within the flexsurv package to allow the $\pi_{r,s}$ to depend upon the covariates and their interactions. Covariates are also included on parameters $\theta_{r,s}$ of the

parametric distributions $f_{r,s}$. The choice of parameters and covariate effects are shown in Supplementary Table 1.

The parametric distributions chosen included the Generalized Gamma, Gamma and Log-normal distributions. The cumulative distribution functions for these distributions are included in [10].

Data linkage

Data linkage to PHE's mortality data was undertaken using a deterministic linkage on NHS number. PHE's mortality data comprised deaths from four sources in order to ensure maximum completeness (the Office for National Statistics (ONS) death registrations, NHSE deaths in hospitals, SGSS and local Health Protection Teams). Death outcomes are included in these data if they occurred within 60 days of a positive COVID-19 test, or COVID-19 was mentioned on the death certificate.

Data linkage to the NHS Hospital Episodes Statistics database was undertaken using a deterministic linkage on NHS number.

Goodness of fit

Goodness of fit curves for the parametric model compared to the non-parametric Aalen-Johansen cumulative incidence estimator are included in the Appendix. The models showed good agreement, with the parametric model estimating increased probability of discharge compared to the Aalen-Johansen estimator due to the two methods assuming different censoring mechanisms.

Supplementary table 1: Model parameters for 'From Hospital' and 'From ICU' sub-models

	'From Hospital' sub-	model	'From ICU' sub-model			
Transition	Discharge	Death	ICU	Discharge	Death	
Parametric distribution	Generalised Gamma	Gamma	Log-normal	Generalised gamma	Gamma	
Covariates included on	Location (µ)	Rate (β)	Mean (µ)	Location (µ)	Rate (β)	

Supplementary table 2: List of SARI-Watch sentinel NHS trusts:

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Alder Hey Children's NHS Foundation Trust
Barking, Havering and Redbridge University Hospitals NHS Trust
Barts Health NHS Trust
Blackpool Teaching Hospitals NHS Foundation Trust
Bolton NHS Foundation Trust
Chesterfield Royal Hospital NHS Foundation Trust
Great Western Hospitals NHS Foundation Trust
James Paget University Hospitals NHS Foundation Trust
King's College Hospital NHS Foundation Trust
Liverpool Heart and Chest Hospital NHS Foundation Trust
Luton And Dunstable University Hospital NHS Foundation Trust
Mid Essex Hospital Services NHS Trust
North Cumbria Integrated Care NHS Foundation Trust
North West Anglia NHS Foundation Trust
Northampton General Hospital NHS Trust
Royal Berkshire NHS Foundation Trust
Royal National Orthopaedic Hospital NHS Trust
Shrewsbury And Telford Hospital NHS Trust
Tameside And Glossop Integrated Care NHS Foundation Trust
The Newcastle Upon Tyne Hospitals NHS Foundation Trust
The Queen Elizabeth Hospital, King's Lynn, NHS Foundation Trust
The Rotherham NHS Foundation Trust
The Royal Orthopaedic Hospital NHS Foundation Trust
University College London Hospitals NHS Foundation Trust
University Hospital Southampton NHS Foundation Trust
Walsall Healthcare NHS Trust
West Hertfordshire Hospitals NHS Trust
Worcestershire Acute Hospitals NHS Trust
Wrightington, Wigan and Leigh NHS Foundation Trust
Yeovil District Hospital NHS Foundation Trust
York Teaching Hospital NHS Foundation Trust

Supplementary table 3: Estimated next event probabilities and 95% confidence intervals for outcomes from hospital admission, by baseline characteristic.

Group	Event	Mar	Apr	May	Jun/Jul/Aug	Sep	Oct	Nov	Dec
All	Death	25.3% (23.8, 26.8)	24.4% (23.4, 25.4)	18% (16.5, 19.7)	9.4% (7.9, 11.1)	16.9% (13.8, 20.1)	18.7% (16.9, 20.5)	19.3% (17.9, 21)	23.1% (20.4, 26)
All	Discharge	60.8% (59.1, 62.5)	65% (63.9, 66.2)	75.8% (73.9, 77.6)	84.3% (82.1, 86.2)	69% (64.6, 72.9)	68.5% (66.4, 70.6)	69.6% (67.7, 71.4)	67.3% (64, 69.9)
All	ICU	13.9% (12.8, 15.2)	10.6% (10, 11.4)	6.2% (5.3, 7.1)	6.3% (5.1, 7.8)	14.2% (11.1, 17.2)	12.8% (11.3, 14.5)	11.1% (10, 12.6)	9.6% (8.6, 10.9)
Sex			,						,
Female	Death	24.1% (22.6, 25.5)	23% (21.8, 24.3)	16.8% (15.3, 18.3)	8.6% (7.2, 10.1)	16.2% (13.2, 19.5)	17.8% (16, 19.6)	18.3% (16.9, 19.9)	21.6% (18.9, 24.5)
Female	Discharge	66.2% (64.5, 67.7)	69.6% (68.2, 71)	78.9% (77, 80.7)		74.1% (70.1, 77.7)	73.2% (71.1, 75.2)	73.8% (72.1, 75.5)	71.6% (68.5, 74.5)
Female	ICU	9.8% (8.8, 10.9)	7.4% (6.8, 8.1)	4.3% (3.6, 5.3)	4.3% (3.4, 5.3)	9.8% (7.4, 12.6)	9.1% (7.9, 10.5)	7.9% (6.9, 8.9)	6.8% (5.9, 7.8)
Male	Death	26% (24.4, 27.6)	25.4% (24.3, 26.6)	19.3% (17.7, 21.3)	10.1% (8.6, 11.7)	17.8% (14.4, 21.3)	19.6% (17.6, 21.4)	20.3% (18.8, 22.1)	24.1% (21, 27.2)
Male	Discharge	57.2% (55.4, 58.9)	61.5% (60.2, 62.8)	72.7% (70.5, 74.5)	81.8% (79.5, 84.1)	65.1% (60.1, 69.7)	64.5% (62.1, 66.7)	65.7% (63.7, 67.8)	63.9% (60.5, 67.3)
Male	ICU	16.8% (15.6, 18.2)	13.1% (12.1, 14)	8% (6.7, 9.6)	8.1% (6.5, 9.9)	17.1% (13.4, 21.3)	15.9% (14.2, 18)	14% (12.4, 15.5)	12% (10.7, 13.6)
Age group									
15-44	Death	1.8% (0.9, 3.5)	1.9% (1.2, 3.2)	0.6% (0.2, 2.7)	0.7% (0.1, 3.1)	0.8% (0.1, 6.3)	0.8% (0.2, 3.4)	0.7% (0.2, 2.4)	1.6% (0.4, 4.9)
15-44	Discharge	85% (80.9, 88.1)	85.9% (82.9, 88.4)	95.1% (91.5, 96.7)	93.1% (88.7, 95.7)	90.2% (82.6, 94.6)	90.7% (86.1, 93.8)	91.5% (88.4, 94.3)	86.6% (81.6, 90.4)
15-44	ICU	13.2% (10.4, 16.9)	12.2% (9.7, 14.8)	4.3% (2.6, 7.3)	6.2% (3.8, 10)	9% (4.6, 15.7)	8.5% (5.5, 12.3)	7.8% (5.3, 10.8)	11.8% (8.5, 15.6)
45-64	Death	7.3% (5.9, 8.9)	6.9% (5.8, 8.2)	5.8% (4.1, 7.8)	1.9% (0.9, 3.8)	4.1% (1.6, 9.1)	4.7% (3.1, 6.8)	5.9% (4.3, 8)	4.5% (2.8, 7.3)
45-64	Discharge	69.2% (66.5, 72)	72.6% (70.6, 74.7)	80.3% (76.4, 83.2)	87.6% (83.9, 90.3)	72.2% (63.7, 79)	74.9% (71.1, 78.5)	75.2% (71.5, 78.5)	78.3% (74.7, 81.9)
45-64	ICU	23.5% (20.9, 26.3)	20.5% (18.7, 22.3)	13.9% (11.5, 17.4)	10.4% (7.9, 14)	23.7% (17.4, 31.3)	20.4% (17.1, 24.3)	18.9% (16, 22.2)	17.1% (14.2, 20.1)
65-74	Death	21.7% (18.7, 25)	22.8% (20.6, 25.2)	16.4% (13.1, 20.5)	7.9% (5, 12.1)	17.4% (10.1, 27.9)	17.6% (14.5, 21.2)	17.3% (14.5, 20.8)	19% (13.8, 24.4)
65-74	Discharge	59.1% (55.3, 63)	62.4% (60, 65.1)	76% (71.2, 79.6)	86.1% (80.7, 89.9)	63.5% (52.3, 72.8)	62.6% (57.8, 66.9)	65% (60.7, 68.8)	69.9% (63.7, 75.3)
65-74	ICU	19.2% (16.3, 22.3)	14.8% (12.8, 16.8)	7.5% (5.3, 10.5)	6% (3.5, 10)	19.1% (12.1, 28.8)	19.7% (16.1, 23.9)	17.6% (14.5, 21)	11.1% (8.4, 14.7)
75+	Death	47.5% (44.7, 50.1)	42% (40.4, 43.8)	30.3% (27.4, 33.3)	21.2% (17.7, 25)	37.1% (29.8, 44.9)	33.8% (30.6, 37.2)	34.2% (31.3, 37)	41% (36.6, 45.5)
75+	Discharge	47.6% (45, 50.2)	56% (54.2, 57.6)	67.5% (64.5, 70.6)	76.4% (72.1, 79.7)	56% (48.8, 64.1)	60.9% (57.6, 64.4)	61.2% (58.4, 63.9)	56.7% (52.1, 61.3)
75+	ICU	4.9% (3.9, 6.2)	2% (1.6, 2.6)	2.2% (1.5, 3.4)	2.4% (1.4, 4.2)	6.9% (3.9, 12.4)	5.3% (3.9, 7)	4.6% (3.6, 6)	2.4% (1.6, 3.6)
Region of residence									
London/South of	Death								
England		22.9% (21, 24.7)	19.3% (18.1, 20.6)	12.7% (10.6, 14.9)	3.7% (2.4, 5.6)	15.8% (8.6, 27.7)	19.2% (14.2, 25.9)	14.6% (11.7, 18.3)	17.1% (13.6, 20.7)
London/South of	Discharge								
England		63.5% (61.6, 65.6)	69.8% (68.5, 71.2)	81.3% (78.6, 83.7)	92.5% (89.5, 94.4)	72.6% (57.8, 82.6)	70.2% (62.6, 76.2)	75.4% (71.6, 79.3)	74.2% (70.3, 77.8)
London/South of	ICU								
England		13.7% (12.2, 15.2)	10.8% (9.8, 11.8)	6.1% (4.7, 8)	3.8% (2.4, 5.9)	11.7% (5.4, 22.4)	10.5% (7, 15.2)	10% (7.5, 12.6)	8.7% (6.8, 11.2)
Midlands and East	Death								
of England		30.5% (27.5, 33.5)	32.6% (30.8, 34.7)	24.4% (21.3, 27.6)	13.2% (10.3, 16.6)	14.7% (9.4, 22.5)	14.8% (12.1, 18)	18.6% (16.2, 21)	24.6% (20.7, 28.9)
Midlands and East	Discharge								
of England		55.6% (52.3, 59)	59.3% (57.1, 61.2)	69.9% (66.7, 73.1)	79% (74.6, 82.6)	74.6% (66.4, 80.8)	71.7% (68.1, 74.9)	72.3% (69.4, 74.8)	68% (63.5, 72.1)
Midlands and East	ICU	10.00/ (10.10.5)	204 (7. 2.2)		7.00((7.7.40.5)	10 70((0.0.47.5)	10 50/ /// 10 5	2 404 (7 7 4 4)	7 40((0, 0)
of England		13.9% (12, 16.6)	8% (7, 9.3)	5.7% (4.2, 7.5)	7.8% (5.7, 10.6)	10.7% (6.8, 17.3)	13.5% (11, 16.6)	9.1% (7.7, 11)	7.4% (6, 9)
North of England	Death	24% (20.8, 28.1)	26.7% (24.4, 28.9)	17.8% (15.4, 20.7)	12% (9.6, 15.3)	17.9% (13.7, 23.1)	20.8% (18.6, 23.3)	22.7% (20, 25.4)	25.5% (20.1, 31.6)
North of England	Discharge	58.8% (54.1, 62.8)	59.5% (56.8, 62.1)	75.7% (72.3, 78.5)	81.3% (77.5, 84.4)	65.3% (58.7, 70.6)	66.2% (63.2, 68.9)	63.7% (60.8, 66.8)	59.6% (52.9, 65.5)
North of England	ICU	17.3% (14, 20.8)	13.8% (11.9, 15.7)	6.6% (5.1, 8.5)	6.7% (4.7, 9.5)	16.7% (12.9, 21.6)	13% (11.1, 15)	13.6% (11.8, 15.7)	14.9% (12, 18.1)
Ethnicity									

Asian	Death	20.4% (16.8, 24.6)	17.7% (15, 20.3)	6.2% (3.4, 10.7)	3.4% (1.5, 7.5)	11.4% (5.9, 21.4)	18.4% (12.5, 24.1)	9.6% (6.2, 14.4)	9.9% (5.5, 16.5)
Asian	Discharge	60.8% (56, 65.2)	64.7% (61.4, 67.8)	86.9% (81.1, 90.9)	88.4% (82.3, 92.5)	73.3% (61.4, 81.3)	64.4% (56.7, 72.4)	73.5% (66.3, 79.3)	79.2% (71.2, 85.2)
Asian	ICU	18.7% (15.3, 22.5)	17.7% (15.3, 20.2)	6.9% (4.2, 11.7)	8.2% (4.4, 13.3)	15.3% (8.8, 24.8)	17.2% (11.9, 24.6)	16.9% (12.3, 23.6)	10.9% (7.1, 16.9)
Black	Death	20.1% (16.6, 23.7)	14.3% (11.7, 17.1)	4.4% (2, 9.3)	0.7% (0.1, 7.3)	12.4% (2.4, 43.9)	15.1% (5.9, 34.3)	26.2% (13.2, 45.1)	14.2% (6.1, 27.7)
Black	Discharge	64% (59.7, 68.2)	72.8% (69.3, 76.1)	83.4% (75.6, 88.7)	95.8% (85.8, 98.3)	61.3% (29.7, 82.3)	73.4% (51.6, 86.1)	60.1% (41, 75.3)	77.6% (62.2, 87)
Black	ICU	15.9% (12.9, 19.1)	12.9% (10.5, 15.6)	12.2% (7.7, 19.4)	3.6% (1.1, 9.7)	26.3% (7.9, 54.1)	11.4% (3.5, 32.8)	13.7% (5.3, 29.8)	8.2% (3.4, 17)
Mixed/Other	Death	13.2% (8.6, 19.1)	11.3% (8.4, 15.6)	9% (4.6, 17.5)	0.6% (0, 16.5)	8.8% (1.4, 34)	9.9% (3.4, 25.9)	4.9% (1.4, 15.4)	4.8% (1.4, 14.7)
Mixed/Other	Discharge	66.8% (59.3, 72.9)	70.2% (65.2, 74.4)	82.7% (72.9, 88.9)	95.7% (76.2, 98.8)	75.8% (46.5, 89.9)	62.9% (45.5, 77.8)	72.4% (58.4, 83.3)	81.2% (69.1, 88.6)
Mixed/Other	ICU	20% (14.6, 26.1)	18.5% (14.9, 23.2)	8.3% (3.9, 17.1)	3.7% (0.8, 12.9)	15.4% (3.9, 39.7)	27.2% (13.3, 44)	22.7% (13.1, 35.3)	13.9% (8.1, 23.8)
White	Death	28.9% (27.3, 31.2)	28.6% (27.4, 30.1)	21% (19.2, 23)	11.8% (9.8, 14)	19.1% (15.3, 23.6)	19.5% (17.6, 21.5)	20.9% (19.1, 22.7)	25.4% (22.2, 28.7)
White	Discharge	58.7% (56.3, 60.4)	63% (61.6, 64.3)	73.9% (71.7, 75.8)	82% (79.3, 84.2)	67.7% (62.5, 72.2)	68% (65.6, 70.2)	68.9% (66.8, 70.9)	66.4% (63, 69.7)
White	ICU	12.3% (11.1, 13.8)	8.4% (7.7, 9.1)	5.1% (4.2, 6.2)	6.2% (4.8, 7.8)	13.2% (10.2, 17.4)	12.5% (10.9, 14.1)	10.2% (8.9, 11.6)	8.2% (7.1, 9.5)
Number of			, ,	, , ,	, ,	,		,	,
comorbidities									
0	Death	9.6% (7.5, 12.1)	11% (9.5, 12.7)	7.8% (5.6, 10.8)	3.3% (1.7, 5.9)	5.9% (2.8, 12)	7% (4.9, 9.6)	7.4% (5.6, 10)	10.2% (7.5, 13.6)
0	Discharge	74.9% (71, 78)	74.1% (71.8, 76.3)	85.4% (81.4, 88.5)	92% (87.9, 94.5)	82.7% (75, 88.1)	80.3% (76.3, 84)	81.2% (77.9, 84)	78.2% (74, 81.8)
0	ICU	15.5% (12.8, 18.6)	14.9% (13.2, 16.7)	6.8% (4.8, 10.1)	4.7% (2.7, 7.7)	11.4% (6.8, 17.8)	12.7% (10, 16.4)	11.4% (9.1, 14.2)	11.6% (9.2, 14.2)
1	Death	16% (13.3, 18.8)	18% (15.9, 20.1)	11.7% (9.2, 15.2)	4.8% (2.9, 8.3)	14.4% (8.8, 22.4)	11.9% (8.8, 15.7)	13.9% (11.1, 17.3)	18.3% (14.4, 23.8)
1	Discharge	65.4% (61.7, 68.8)	68.8% (66.2, 71)	79.1% (74.3, 82.4)	88.9% (84.4, 92.1)	76.3% (67.5, 83.4)	73.5% (68.2, 78.1)	72.4% (68.3, 76.1)	72% (66.6, 76.3)
1	ICU	18.6% (15.6, 22)	13.2% (11.7, 15.2)	9.2% (6.8, 12.8)	6.3% (3.9, 10)	9.3% (5.2, 16.8)	14.6% (11.1, 18.8)	13.7% (10.9, 17)	9.7% (7.5, 12.6)
2	Death	22.8% (19.7, 26.2)	27% (24.8, 29.2)	17.6% (13.9, 21.6)	13.9% (10.1, 19.1)	21% (14.2, 31.2)	19.1% (15.6, 23.8)	20.9% (17.6, 24.8)	26.9% (21.5, 32.9)
2	Discharge	61.1% (57.4, 64.7)	61.9% (59.3, 64.6)	75% (71, 78.9)	79.8% (73.8, 84)	61% (49.7, 71)	65.9% (60.6, 69.9)	67.4% (62.9, 71.3)	62.1% (56, 67.9)
2	ICU	16.1% (13.4, 19.1)	11.1% (9.6, 12.9)	7.4% (5.3, 10.5)	6.3% (3.7, 10)	18% (10.9, 26.3)	15% (11.4, 19.3)	11.7% (9, 14.9)	10.9% (8.1, 14.5)
3+	Death	35.8% (33.6, 38.2)	32.3% (30.8, 33.8)	25.1% (22.4, 27.8)	13.5% (10.8, 16.2)	26.3% (19.4, 33.8)	28.8% (25.7, 32.1)	29.8% (27, 32.9)	31.9% (27.4, 37)
3+	Discharge	53% (50.4, 55.8)	60.4% (58.6, 62)	70.8% (67.9, 73.6)	79.9% (75.9, 82.9)	56.5% (48.2, 64.6)	60.4% (57, 63.9)	61.1% (57.8, 64.1)	61.9% (56.8, 66.3)
3+	ICU	11.2% (9.5, 12.9)	7.3% (6.5, 8.4)	4.1% (3, 5.4)	6.7% (4.9, 9.2)	17.2% (11.9, 24.8)	10.8% (8.8, 13.1)	9.2% (7.5, 11.2)	6.3% (4.7, 8.8)
								. , . ,	

Supplementary table 4: Estimated next event probabilities and 95% confidence intervals for outcome from ICU admission, by baseline characteristic.

Group	Event	Mar	Apr	May	Jun/Jul/Aug	Sep	Oct	Nov	Dec
All	Death	47.4% (42.5, 51.7)	47.5% (44, 51.2)	31% (23.1, 39.8)	24.1% (16.1, 35.1)	33.4% (23.5, 45.4)	40.2% (34.1, 46.6)	37% (31.7, 42.7)	26.8% (20.2, 34.2)
All	Discharge	52.6% (48.3, 57.5)	52.5% (48.8, 56)	69% (60.2, 76.9)	75.9% (64.9, 83.9)	66.6% (54.6, 76.5)	59.8% (53.4, 65.9)	63% (57.3, 68.3)	73.2% (65.8, 79.8)
Sex									
Female	Death	34.8% (26.9, 42.8)	41.7% (35.2, 48.2)	24.5% (14.7, 39.1)	16.2% (7.2, 35.5)	21.3% (10.2, 42.4)	24.1% (15, 35.3)	32.6% (24.7, 42.9)	23.6% (13.5, 36.6)
Female	Discharge	65.2% (57.2, 73.1)	58.3% (51.8, 64.8)	75.5% (60.9, 85.3)	83.8% (64.5, 92.8)	78.7% (57.6, 89.8)	75.9% (64.7, 85)	67.4% (57.1, 75.3)	76.4% (63.4, 86.5)
Male	Death	54.7% (49.1, 59.3)	49.7% (45.2, 53.8)	32.6% (24.4, 42.6)	26.7% (16.7, 41.5)	37.4% (24, 51.7)	46.7% (39.4, 53.4)	39.8% (31.9, 48)	26.5% (19.2, 36)
Male	Discharge	45.3% (40.7, 50.9)	50.3% (46.2, 54.8)	67.4% (57.4, 75.6)	73.3% (58.5, 83.3)	62.6% (48.3, 76)	53.3% (46.6, 60.6)	60.2% (52, 68.1)	73.5% (64, 80.8)
Age group									
15-44	Death	20.5% (11.6, 32.4)	13% (7.5, 21.7)	10.1% (2, 43.7)	8.2% (1.3, 36.9)	11.1% (0.8, 66)	13.1% (3.7, 35.8)	10.4% (3.2, 27.6)	9.3% (3, 26.3)
15-44	Discharge	79.5% (67.6, 88.4)	87% (78.3, 92.5)	89.9% (56.3, 98)	91.8% (63.1, 98.7)	88.9% (34, 99.2)	86.9% (64.2, 96.3)	89.6% (72.4, 96.8)	90.7% (73.7, 97)
45-64	Death	42.2% (36, 47.6)	43.7% (39, 48.5)	24.3% (16.5, 35.8)	14% (6.1, 27.5)	10% (3.6, 27.5)	24% (16.2, 34.7)	27.5% (20.2, 35.9)	23.7% (15.4, 36.7)
45-64	Discharge	57.8% (52.4, 64)	56.3% (51.5, 61)	75.7% (64.2, 83.5)	86% (72.5, 93.9)	90% (72.5, 96.4)	76% (65.3, 83.8)	72.5% (64.1, 79.8)	76.3% (63.3, 84.6)

65-74	Death	63.1% (55, 71.5)	61.4% (53.7, 68.2)	33.6% (17.7, 53.5)	39.9% (18.3, 65.3)	59.2% (32.8, 79.2)	49.3% (39.1, 61.2)	40.9% (30.8, 51)	27.3% (14, 46.1)
65-74	Discharge	36.9% (28.5, 45)	38.6% (31.8, 46.3)	66.4% (46.5, 82.3)	60.1% (34.7, 81.7)	40.8% (20.8, 67.2)	50.7% (38.8, 60.9)	59.1% (49, 69.2)	72.7% (53.9, 86)
75+	Death	77.4% (65.1, 85.9)	75.3% (65, 84.8)	51.9% (31.2, 71.5)	49.5% (25.6, 75)	60.2% (32.6, 82)	76% (61.3, 86.1)	65.1% (49.2, 77.3)	70.5% (44.4, 88.5)
75+	Discharge	22.6% (14.1, 34.9)	24.7% (15.2, 35)	48.1% (28.5, 68.8)	50.5% (25, 74.4)	39.8% (18, 67.4)	24% (13.9, 38.7)	34.9% (22.7, 50.8)	29.5% (11.5, 55.6)
Region of	J	, , , , , ,	, , , , , , ,	(, ,	,	, , , , , ,	, , , , , ,	, , , , , , , , , , , , , , , , , , , ,	
residence									
London/South of	Death								
England		47.1% (41.1, 53.1)	48.3% (43.5, 52.5)	30.4% (20, 44.5)	23.8% (9.3, 46.8)	32.5% (5.7, 74.5)	44.4% (21.1, 69.6)	24.3% (14.3, 38.6)	24.8% (14.1, 39.6)
London/South of	Discharge								
England		52.9% (46.9, 58.9)	51.7% (47.5, 56.5)	69.6% (55.5, 80)	76.2% (53.2, 90.7)	67.5% (25.5, 94.3)	55.6% (30.4, 78.9)	75.7% (61.4, 85.7)	75.2% (60.4, 85.9)
Midlands and East	Death								
of England		57% (47.9, 64.9)	57.9% (50.4, 65.9)	38.3% (24.7, 52.6)	21% (11.3, 37.8)	35.6% (15.4, 61.8)	50.6% (40.7, 60.7)	47.1% (37.4, 56.8)	32.5% (21.7, 44)
Midlands and East	Discharge								
of England		43% (35.1, 52.1)	42.1% (34.1, 49.6)	61.7% (47.4, 75.3)	79% (62.2, 88.7)	64.4% (38.2, 84.6)	49.4% (39.3, 59.3)	52.9% (43.2, 62.6)	67.5% (56, 78.3)
North of England	Death	47.3% (36.9, 57.2)	35.6% (28.6, 43)	19.5% (10.8, 34.2)	21.9% (9.5, 40.8)	30.2% (18.5, 44.7)	33.8% (27.3, 40.9)	33.7% (26.1, 42.4)	21.1% (12.4, 34.8)
North of England	Discharge	52.7% (42.8, 63.1)	64.4% (57, 71.4)	80.5% (65.8, 89.2)	78.1% (59.2, 90.5)	69.8% (55.3, 81.5)	66.2% (59.1, 72.7)	66.3% (57.6, 73.9)	78.9% (65.2, 87.6)
Ethnicity									
Asian	Death	52.2% (45.8, 58.9)	51.8% (46.1, 58)	33.6% (24, 43.8)	25.7% (16.2, 37.7)	35% (22.9, 48.1)	44.7% (36.1, 52.5)	39.5% (31.9, 48.3)	28.3% (19.9, 37.4)
Asian	Discharge	47.8% (41.1, 54.2)	48.2% (42, 53.9)	66.4% (56.2, 76)	74.3% (62.3, 83.8)	65% (51.9, 77.1)	55.3% (47.5, 63.9)	60.5% (51.7, 68.1)	71.7% (62.6, 80.1)
Black	Death	48.2% (41.1, 55.7)	47.8% (40, 55.2)	30.2% (21.7, 41.1)	22.8% (13.5, 34)	31.5% (20, 44.5)	40.8% (31.9, 51)	35.8% (27.2, 45.3)	25.2% (16.8, 35.4)
Black	Discharge	51.8% (44.3, 58.9)	52.2% (44.8, 60)	69.8% (58.9, 78.3)	77.2% (66, 86.5)	68.5% (55.5, 80)	59.2% (49, 68.1)	64.2% (54.7, 72.8)	74.8% (64.6, 83.2)
Mixed/Other	Death	37.6% (29.1, 46.7)	37.3% (28.9, 45.9)	21.9% (13.7, 31.5)	16.1% (8.6, 27)	23% (13.3, 34.2)	30.9% (22.3, 41.7)	26.5% (18.3, 36.2)	17.9% (11.5, 26.8)
Mixed/Other	Discharge	62.4% (53.3, 70.9)	62.7% (54.1, 71.1)	78.1% (68.5, 86.3)	83.9% (73, 91.4)	77% (65.8, 86.7)	69.1% (58.3, 77.7)	73.5% (63.8, 81.7)	82.1% (73.2, 88.5)
White	Death	48.5% (43.4, 53.3)	48.1% (44.1, 52.4)	30.4% (22.6, 38.6)	23% (14.6, 33.7)	31.7% (21, 43.1)	41% (34.8, 47.4)	36% (29.4, 42.5)	25.4% (18.4, 32.4)
White	Discharge	51.5% (46.7, 56.6)	51.9% (47.6, 55.9)	69.6% (61.4, 77.4)	77% (66.3, 85.4)	68.3% (56.9, 79)	59% (52.6, 65.2)	64% (57.5, 70.6)	74.6% (67.6, 81.6)
Number of									
comorbidities									
0	Death	42.2% (32.2, 51.6)	40.1% (32.8, 46.6)	24.4% (10.7, 45.4)	21.3% (6.5, 51.1)	25% (10.1, 51.9)	41.9% (28.7, 54.4)	34% (23.5, 45.3)	22.1% (12.4, 35.6)
0	Discharge	57.8% (48.4, 67.8)	59.9% (53.4, 67.2)	75.6% (54.6, 89.3)	78.7% (48.9, 93.5)	75% (48.1, 89.9)	58.1% (45.6, 71.3)	66% (54.7, 76.5)	77.9% (64.4, 87.6)
1	Death	43.4% (33.7, 52.6)	47.5% (40.7, 55.4)	32.4% (19.2, 49.4)	15.9% (5.6, 39.9)	28.2% (10.5, 57.5)	36.2% (24.9, 49.3)	36.1% (25.7, 47.6)	25.1% (12.3, 42.8)
1	Discharge	56.6% (47.4, 66.3)	52.5% (44.6, 59.3)	67.6% (50.6, 80.8)	84.1% (60.1, 94.4)	71.8% (42.5, 89.5)	63.8% (50.7, 75.1)	63.9% (52.4, 74.3)	74.9% (57.2, 87.7)
2	Death	57.4% (47.4, 65.8)	48.9% (40.9, 56.4)	29.5% (15.9, 48.2)	12.6% (3.6, 39)	33.5% (16.3, 60.8)	41.7% (30.3, 53.6)	42.2% (29.7, 54.9)	16.6% (7.3, 32.4)
2	Discharge	42.6% (34.2, 52.6)	51.1% (43.6, 59.1)	70.5% (51.8, 84.1)	87.4% (61, 96.4)	66.5% (39.2, 83.7)	58.3% (46.4, 69.7)	57.8% (45.1, 70.3)	83.4% (67.6, 92.7)
3+	Death	50.7% (43.2, 58.3)	53% (46.6, 59.2)	33.5% (22.3, 46.2)	28.2% (15.5, 44.8)	30.4% (15.1, 51.8)	42% (31.4, 52.3)	38.6% (28.2, 48.9)	42% (27, 57.4)
3+	Discharge	49.3% (41.7, 56.8)	47% (40.8, 53.4)	66.5% (53.8, 77.7)	71.8% (55.2, 84.5)	69.6% (48.2, 84.9)	58% (47.7, 68.6)	61.4% (51.1, 71.8)	58% (42.6, 73)

Supplementary table 5: Estimated hospitalised fatality risk and 95% confidence intervals, by baseline characteristic.

Group	Mar	Apr	May	Jun/Jul/Aug	Sep	Oct	Nov	Dec
All	31.9% (30.3, 33.5)	29.5% (28.4, 30.5)	19.9% (18.3, 21.6)	10.9% (9.4, 12.7)	21.6% (18.4, 25.5)	23.8% (22.1, 25.9)	23.4% (21.8, 25)	25.7% (23, 29.2)
Sex								
Female	27.5% (25.6, 29.4)	26.1% (24.8, 27.4)	17.9% (16.4, 19.7)	9.3% (7.9, 11.1)	18.2% (14.8, 22.2)	20% (18.2, 21.9)	20.9% (19.3, 22.6)	23.2% (20.3, 26.3)

Male	35.2% (33.4, 36.9)	31.9% (30.6, 33.2)	21.9% (20.2, 23.9)	12.2% (10.4, 14.3)	24.2% (20.2, 28.5)	27% (24.9, 29.1)	25.9% (24.1, 28)	27.3% (24.2, 30.4)
Age group		(0010, 001=)			, (,,,			
15-44	4.5% (2.9, 6.8)	3.5% (2.4, 5.1)	1.1% (0.4, 3.5)	1.2% (0.4, 4.5)	1.8% (0.3, 9.5)	1.9% (0.8, 5.3)	1.5% (0.6, 3.8)	2.6% (1.3, 6.9)
45-64	17.2% (15.1, 19.6)	15.9% (14.4, 17.5)	9.2% (6.9, 11.9)	3.4% (2, 5.7)	6.4% (3.6, 12.2)	9.6% (7.3, 12.4)	11.1% (8.8, 13.9)	8.6% (6.3, 11.9)
65-74	33.8% (30, 37.8)	31.9% (29.6, 34.6)	19% (15.2, 23.6)	10.3% (7, 15)	28.7% (19.3, 39.9)	27.4% (23.4, 32.1)	24.6% (21.4, 28.3)	22% (16.6, 27.3)
75+	51.3% (48.6, 54.1)	43.5% (41.7, 45.3)	31.4% (28.8, 34.1)	22.4% (18.8, 26.4)	41.2% (34.1, 49)	37.8% (34.4, 41.4)	37.2% (34.1, 40)	42.6% (38.3, 46.8)
Region of residence								
London/South of								
England	29.3% (27.4, 31.2)	24.6% (23.1, 26)	14.5% (12.4, 17.1)	4.6% (3.1, 7.1)	19.6% (11.2, 33.1)	23.9% (18, 30.2)	17% (14.3, 20.4)	19.3% (16.1, 23.3)
Midlands and East								
of England	38.4% (35.2, 41.9)	37.3% (35.1, 39.4)	26.5% (23.5, 29.6)	14.9% (12, 18.5)	18.5% (13, 26.8)	21.6% (18.7, 25.1)	22.9% (20.6, 25.8)	27% (22.9, 31.6)
North of England	32.1% (27.9, 36.7)	31.6% (29.3, 34.1)	19.1% (16.2, 22.3)	13.5% (10.3, 17)	23% (18.3, 29)	25.2% (22.7, 28)	27.3% (24.4, 30.2)	28.6% (23.3, 34.8)
Ethnicity								
Asian	30.2% (26.3, 34.4)	26.8% (24.2, 29.6)	8.5% (5.6, 12.9)	5.5% (3.3, 10)	16.7% (10.6, 26.2)	26% (20.2, 32.8)	16.3% (12.6, 21.8)	13% (9, 19.3)
Black	27.8% (24.4, 31.8)	20.5% (17.5, 23.7)	8.1% (4.9, 14.1)	1.5% (0.5, 9.7)	20.7% (7.9, 48)	19.8% (10.1, 37.7)	31.1% (18, 47.6)	16.2% (8.2, 32.5)
Mixed/Other	20.7% (15.8, 27.2)	18.2% (14.9, 22.4)	10.8% (6.1, 18.5)	1.2% (0.3, 17.2)	12.3% (4.2, 36.3)	18.3% (9.8, 35)	10.9% (6.5, 22)	7.3% (3.3, 18.6)
White	34.9% (33, 37)	32.6% (31.4, 34)	22.6% (20.8, 24.8)	13.2% (11.5, 15.7)	23.3% (19.4, 28.1)	24.6% (22.6, 26.8)	24.6% (22.8, 26.3)	27.4% (24.3, 30.8)
Number of comorbidities								
0	16.1% (13.4, 19.1)	17% (15.2, 18.9)	9.5% (7.1, 12.8)	4.3% (2.5, 7.7)	8.8% (5.1, 16.6)	12.3% (9.3, 15.8)	11.3% (9.1, 14.3)	12.8% (9.6, 16.4)
1	24.1% (20.8, 27.4)	24.3% (21.9, 26.7)	14.7% (11.6, 18)	5.8% (3.5, 9.7)	17% (11.9, 25.7)	17.2% (13.7, 21.8)	18.9% (15.6, 22.1)	20.7% (16.2, 25.8)
2	32% (28.9, 36.2)	32.5% (29.9, 34.9)	19.8% (16.2, 23.8)	14.7% (10.7, 20.4)	27% (18.6, 39.2)	25.3% (21.4, 29.5)	25.8% (22.4, 30.2)	28.7% (23.5, 35.4)
3+	41.4% (39, 43.8)	36.2% (34.4, 37.7)	26.5% (23.9, 29.4)	15.3% (12.6, 18.7)	31.5% (23.7, 39.6)	33.4% (30.1, 37.1)	33.3% (29.9, 36.5)	34.5% (29.9, 38.9)

Supplementary table 6: Estimated median time (in days) to next event from hospital admission and 95% confidence interval, by baseline characteristic.

Group	Event	Mar	Apr	May	Jun/Jul/Aug	Sep	Oct	Nov	Dec
All	Death	6.6 (6.2, 7.1)	6.6 (6.3, 6.9)	8 (7.4, 8.8)	9.9 (8.6, 11.7)	9 (7.2, 11.1)	9 (8.2, 9.9)	9.3 (8.5, 10.1)	12.3 (10.9, 14)
All	Discharge	6.1 (5.7, 6.5)	6.2 (5.9, 6.5)	5.1 (4.8, 5.4)	4.1 (3.8, 4.5)	7.3 (6.2, 8.5)	10.2 (9.3, 11.2)	7.1 (6.7, 7.7)	9.3 (8.5, 10.3)
All	ICU	1.1 (1, 1.2)	1.2 (1.1, 1.2)	1.3 (1.1, 1.5)	1.1 (0.9, 1.4)	1.3 (1, 1.7)	1.1 (1, 1.3)	1 (0.9, 1.1)	0.8 (0.7, 0.9)
Sex									
Female	Death	6.5 (6, 7)	6.5 (6.1, 6.9)	7.9 (7.1, 8.8)	9.8 (8.3, 11.5)	8.8 (7.1, 11)	8.9 (8, 9.9)	9.2 (8.4, 10)	12 (10.6, 13.6)
Female	Discharge	5.8 (5.4, 6.2)	5.9 (5.5, 6.2)	4.8 (4.4, 5.2)	3.9 (3.5, 4.3)	6.9 (5.9, 8.2)	9.8 (8.9, 10.6)	6.8 (6.3, 7.3)	8.9 (8, 10)
Female	ICU	1.1 (1, 1.3)	1.2 (1.1, 1.3)	1.3 (1.1, 1.6)	1.1 (0.9, 1.4)	1.3 (1.1, 1.7)	1.2 (1, 1.3)	1 (0.9, 1.1)	0.8 (0.7, 1)
Male	Death	6.7 (6.2, 7.2)	6.7 (6.3, 7.1)	8.1 (7.3, 9)	10 (8.6, 11.6)	9 (7.4, 11.2)	9.1 (8.3, 10.1)	9.4 (8.6, 10.3)	12.3 (10.9, 14)
Male	Discharge	6.4 (6, 6.8)	6.4 (6.1, 6.8)	5.3 (4.9, 5.7)	4.2 (3.8, 4.7)	7.6 (6.5, 9)	10.7 (9.8, 11.7)	7.5 (6.9, 8.1)	9.8 (8.8, 10.9)
Male	ICU	1.1 (1, 1.2)	1.2 (1.1, 1.2)	1.3 (1.1, 1.5)	1.1 (0.9, 1.3)	1.3 (1, 1.7)	1.1 (1, 1.3)	1 (0.9, 1.1)	0.8 (0.7, 0.9)
Age group									
15-44	Death	7.5 (5.1, 10.5)	7.5 (5.2, 10.4)	9.2 (6.4, 12.9)	11.3 (7.9, 15.9)	10.2 (6.9, 14.4)	10.2 (7.1, 14.3)	10.4 (7.5, 14.7)	12.8 (9, 18)
15-44	Discharge	2.9 (2.7, 3.2)	2.8 (2.6, 3)	2.3 (2.1, 2.5)	2 (1.8, 2.2)	3.9 (3.3, 4.6)	4.8 (4.3, 5.2)	3.4 (3.1, 3.7)	4.8 (4.4, 5.3)
15-44	ICU	0.9 (0.8, 1.1)	1 (0.9, 1.1)	1.1 (0.9, 1.3)	0.9 (0.7, 1.2)	1.1 (0.9, 1.4)	1 (0.8, 1.1)	0.8 (0.7, 1)	0.7 (0.6, 0.8)

45-64	Death	7.3 (6.5, 8.2)	7.3 (6.5, 8.2)	9 (7.9, 10.3)	11.1 (9.2, 13.1)	10 (7.8, 12.3)	10 (8.7, 11.4)	10.2 (9, 11.5)	12.5 (10.8, 14.6)
45-64	Discharge	4.9 (4.6, 5.3)	4.6 (4.4, 4.9)	3.9 (3.6, 4.2)	3.3 (3, 3.6)	6.6 (5.6, 7.7)	7.9 (7.2, 8.7)	5.6 (5.2, 6.1)	8 (7.3, 8.8)
45-64	ICU	1.1 (1, 1.2)	1.2 (1.1, 1.3)	1.3 (1.1, 1.5)	1.1 (0.9, 1.4)	1.3 (1, 1.7)	1.1 (1, 1.3)	1 (0.9, 1.1)	0.8 (0.7, 1)
65-74	Death	7.1 (6.4, 7.8)	7.1 (6.5, 7.7)	8.7 (7.8, 9.7)	10.7 (9.2, 12.4)	9.7 (7.7, 11.8)	9.7 (8.7, 10.9)	9.9 (8.9, 10.9)	12.2 (10.9, 13.8)
65-74	Discharge	7.1 (6.6, 7.7)	6.7 (6.3, 7.2)	5.6 (5.1, 6.1)	4.8 (4.4, 5.3)	9.5 (8.2, 11.3)	11.5 (10.5, 12.8)	8.1 (7.5, 8.9)	11.7 (10.5, 13)
65-74	ICU	1.1 (1, 1.2)	1.2 (1.1, 1.3)	1.3 (1.1, 1.5)	1.1 (0.9, 1.4)	1.3 (1, 1.7)	1.1 (1, 1.3)	1 (0.9, 1.1)	0.8 (0.7, 1)
75+	Death	6.4 (5.9, 6.9)	6.4 (6, 6.7)	7.9 (7.1, 8.6)	9.7 (8.4, 11.2)	8.7 (7.2, 10.6)	8.8 (7.9, 9.6)	9 (8.3, 9.7)	11.1 (10, 12.4)
75+	Discharge	10.9 (10.1, 11.6)	10.3 (9.8, 10.9)	8.6 (7.9, 9.3)	7.4 (6.7, 8.1)	14.5 (12.4, 17.2)	17.6 (16.1, 19.3)	12.5 (11.5, 13.4)	17.8 (16.2, 19.7)
75+	ICU	1.3 (1.1, 1.4)	1.3 (1.1, 1.5)	1.5 (1.2, 1.8)	1.3 (1, 1.6)	1.5 (1.1, 2)	1.3 (1.1, 1.5)	1.1 (1, 1.3)	0.9 (0.8, 1.1)
Region of residence									
London/South of England	Death	6.6 (6.1, 7.1)	6.6 (6.2, 7)	8.1 (7.2, 9.1)	9.9 (8.2, 11.5)	8.9 (7.1, 11.1)	9 (8, 10.1)	9.3 (8.4, 10.2)	12.1 (10.4, 13.7)
London/South of England	Discharge	5.3 (5, 5.7)	5.3 (5, 5.5)	4.1 (3.7, 4.4)	3.4 (3.1, 3.7)	5.2 (4.4, 6.2)	7.4 (6.7, 8.2)	5.5 (5, 6)	7.9 (7.2, 8.9)
London/South of England	ICU	1.1 (1, 1.2)	1.1 (1, 1.2)	1.2 (1, 1.4)	1 (0.8, 1.2)	1.2 (0.9, 1.6)	1 (0.9, 1.2)	0.9 (0.8, 1)	0.7 (0.6, 0.9)
Midlands and East of England	Death	6.6 (6.1, 7.2)	6.6 (6.2, 7)	8 (7.3, 9)	9.9 (8.4, 11.5)	8.9 (7.2, 11)	8.9 (8, 10)	9.2 (8.5, 10.2)	12 (10.6, 13.5)
Midlands and East of England	Discharge	6.7 (6.2, 7.2)	6.6 (6.2, 7)	5.1 (4.7, 5.4)	4.2 (3.8, 4.6)	6.6 (5.5, 7.8)	9.2 (8.4, 10.3)	6.9 (6.3, 7.4)	9.9 (9, 11.1)
Midlands and East	ICU								
of England		1.3 (1.1, 1.4)	1.3 (1.2, 1.5)	1.5 (1.2, 1.7)	1.2 (0.9, 1.5)	1.5 (1.2, 1.9)	1.3 (1.1, 1.5)	1.1 (1, 1.3)	0.9 (0.8, 1)
North of England	Death	6.6 (6, 7.3)	6.6 (6.1, 7.1)	8.1 (7.3, 9)	9.9 (8.5, 11.5)	9 (7.3, 11.2)	9 (8.1, 10)	9.3 (8.5, 10.2)	12.1 (10.5, 13.7)
North of England	Discharge	9.3 (8.5, 10.1)	9.2 (8.6, 9.8)	7.1 (6.4, 7.7)	5.8 (5.3, 6.5)	9.1 (7.7, 10.6)	12.8 (11.8, 14)	9.5 (8.6, 10.4)	13.8 (12.3, 15.6)
North of England	ICU	1.1 (1, 1.3)	1.2 (1, 1.3)	1.3 (1.1, 1.5)	1 (0.8, 1.3)	1.3 (1, 1.6)	1.1 (1, 1.2)	0.9 (0.8, 1.1)	0.8 (0.7, 0.9)
Ethnicity									
Asian	Death	5.7 (5, 6.5)	5.7 (5, 6.5)	6.8 (5.8, 8)	8.4 (6.9, 10.4)	7.6 (6, 9.8)	7.8 (6.6, 9)	7.9 (6.8, 9.1)	10.4 (8.7, 12.4)
Asian	Discharge	4.4 (4, 4.8)	4.4 (4.1, 4.8)	3.5 (3.2, 3.9)	2.9 (2.6, 3.2)	5.1 (4.3, 6.2)	6.7 (6, 7.5)	4.8 (4.3, 5.3)	6.5 (5.8, 7.3)
Asian	ICU	1.1 (0.9, 1.2)	1.1 (1, 1.3)	1.3 (1, 1.5)	1.1 (0.8, 1.3)	1.3 (1, 1.7)	1.1 (0.9, 1.3)	0.9 (0.8, 1.1)	0.8 (0.7, 1)
Black	Death	5.7 (4.7, 6.5)	5.6 (4.7, 6.5)	6.7 (5.5, 7.9)	8.4 (6.6, 10.4)	7.5 (5.8, 9.6)	7.7 (6.3, 9)	7.8 (6.6, 9.1)	10.3 (8.6, 12.3)
Black	Discharge	5 (4.5, 5.5)	5 (4.5, 5.4)	3.9 (3.5, 4.4)	3.3 (2.9, 3.6)	5.8 (4.7, 7)	7.6 (6.6, 8.6)	5.4 (4.8, 6)	7.3 (6.3, 8.3)
Black	ICU	1.1 (0.9, 1.3)	1.1 (1, 1.3)	1.2 (1, 1.6)	1 (0.8, 1.4)	1.3 (1, 1.8)	1.1 (0.9, 1.3)	0.9 (0.8, 1.1)	0.8 (0.7, 1)
Mixed/Other	Death	6.8 (5.2, 8.6)	6.7 (5.2, 8.4)	8 (6.2, 10.2)	9.9 (7.4, 12.9)	8.9 (6.5, 12)	9.1 (6.9, 11.4)	9.3 (7.1, 11.6)	12.1 (9.3, 15.5)
Mixed/Other	Discharge	4.9 (4.3, 5.6)	4.9 (4.3, 5.6)	3.8 (3.3, 4.4)	3.2 (2.8, 3.6)	5.6 (4.6, 7)	7.4 (6.3, 8.6)	5.2 (4.6, 6.1)	7.1 (6.1, 8.3)
Mixed/Other	ICU	0.9 (0.8, 1.1)	1 (0.8, 1.1)	1.1 (0.8, 1.3)	0.9 (0.7, 1.2)	1.1 (0.8, 1.5)	0.9 (0.7, 1.1)	0.8 (0.7, 1)	0.7 (0.6, 0.8)
White	Death	6.9 (6.4, 7.4)	6.8 (6.5, 7.2)	8.1 (7.4, 8.9)	10 (8.5, 11.7)	9 (7.3, 11)	9.2 (8.2, 10.1)	9.4 (8.6, 10.1)	12.2 (10.7, 13.8)
White	Discharge	7.1 (6.6, 7.6)	7.1 (6.8, 7.5)	5.6 (5.2, 6)	4.6 (4.3, 5.1)	8.2 (7, 9.9)	10.8 (9.9, 11.9)	7.7 (7.2, 8.3)	10.4 (9.4, 11.6)
White	ICU	1.2 (1.1, 1.3)	1.2 (1.1, 1.3)	1.3 (1.1, 1.6)	1.1 (0.9, 1.4)	1.4 (1.1, 1.9)	1.2 (1, 1.3)	1 (0.9, 1.1)	0.9 (0.8, 1)
Number of comorbidities									
0	Death	7.2 (6.2, 8.1)	7.1 (6.3, 7.9)	8.7 (7.6, 10.1)	10.7 (8.8, 12.5)	9.5 (7.6, 11.9)	9.8 (8.5, 11.1)	10 (8.7, 11.5)	12.4 (10.7, 14.5)
0	Discharge	3.9 (3.7, 4.2)	4 (3.8, 4.2)	3.2 (3, 3.5)	2.7 (2.4, 2.9)	5.2 (4.4, 6.1)	6.9 (6.2, 7.5)	4.9 (4.5, 5.4)	6.7 (6.1, 7.5)
0	ICU	1.1 (1, 1.2)	1.1 (1, 1.2)	1.2 (1, 1.5)	1 (0.8, 1.3)	1.3 (1, 1.6)	1.1 (0.9, 1.3)	1 (0.8, 1.1)	0.8 (0.7, 0.9)

1	Death	7.2 (6.4, 7.9)	7.1 (6.5, 7.7)	8.7 (7.8, 9.8)	10.7 (8.9, 12.4)	9.5 (7.7, 11.8)	9.7 (8.7, 10.9)	10 (8.9, 11.1)	12.4 (10.8, 14.1)
1	Discharge	5 (4.6, 5.4)	5 (4.7, 5.3)	4 (3.7, 4.4)	3.4 (3, 3.7)	6.5 (5.5, 7.8)	8.6 (7.9, 9.5)	6.2 (5.6, 6.7)	8.5 (7.7, 9.5)
1	ICU	1.1 (1, 1.2)	1.1 (1, 1.2)	1.2 (1.1, 1.5)	1 (0.8, 1.3)	1.3 (1, 1.6)	1.1 (1, 1.3)	1 (0.8, 1.1)	0.8 (0.7, 0.9)
2	Death	6.9 (6.3, 7.6)	6.9 (6.3, 7.4)	8.5 (7.6, 9.5)	10.4 (8.7, 12.2)	9.2 (7.5, 11.5)	9.5 (8.5, 10.6)	9.7 (8.8, 10.7)	12.1 (10.6, 13.8)
2	Discharge	6.7 (6.1, 7.2)	6.7 (6.3, 7.2)	5.4 (5, 5.9)	4.5 (4, 5)	8.8 (7.3, 10.5)	11.6 (10.5, 12.8)	8.3 (7.6, 9.1)	11.4 (10.2, 12.8)
2	ICU	1.1 (1, 1.3)	1.2 (1.1, 1.3)	1.3 (1.1, 1.6)	1.1 (0.9, 1.4)	1.3 (1.1, 1.7)	1.1 (1, 1.3)	1 (0.9, 1.1)	0.8 (0.7, 1)
3+	Death	6.3 (5.9, 6.8)	6.3 (5.9, 6.6)	7.8 (7, 8.6)	9.6 (8.1, 11.1)	8.4 (6.8, 10.4)	8.7 (7.9, 9.7)	8.9 (8.2, 9.7)	11.1 (9.9, 12.7)
3+	Discharge	8.3 (7.8, 9)	8.4 (8, 8.9)	6.8 (6.3, 7.3)	5.6 (5.1, 6.2)	11 (9.3, 12.9)	14.5 (13.2, 15.9)	10.4 (9.6, 11.3)	14.3 (12.8, 16)
3+	ICU	1.2 (1.1, 1.3)	1.2 (1.1, 1.4)	1.4 (1.1, 1.6)	1.2 (0.9, 1.4)	1.4 (1.1, 1.8)	1.2 (1.1, 1.4)	1.1 (0.9, 1.2)	0.9 (0.8, 1)

Supplementary table 7: Estimated median time (in days) to next event from ICU admission and 95% confidence interval, by baseline characteristic.

Group	Event	Mar	Apr	May	Jun/Jul/Aug	Sep	Oct	Nov	Dec
All	Death	9.4 (8.4, 10.6)	8.6 (7.8, 9.5)	10.2 (8.1, 13.3)	12.5 (8.6, 16.8)	11 (7.2, 15.8)	10.7 (9.1, 12.6)	11.3 (9.4, 13.5)	9.9 (7.5, 13.1)
All	Discharge	24.4 (21.1, 28.5)	23.8 (21.2, 26.6)	18.3 (14.3, 23.8)	13.8 (10.2, 18.5)	18.9 (13.6, 26.3)	16.8 (14.1, 20.3)	22.8 (18.8, 26.6)	38 (29, 48.9)
Sex									
Female	Death	8.9 (7.4, 10.4)	8.1 (6.9, 9.5)	9.5 (7.2, 12.2)	12 (8.5, 17.8)	10.3 (6.8, 15.3)	10.1 (8.1, 12.4)	10.7 (8.7, 12.9)	9.3 (6.6, 12.8)
Female	Discharge	21.4 (18.2, 25.6)	20.6 (17.6, 23.7)	16.1 (12.2, 20.7)	12.1 (8.9, 16.5)	16.7 (11.2, 23.5)	14.5 (11.6, 17.6)	20.1 (16.4, 24.6)	34.1 (26.6, 42.6)
Male	Death	9.6 (8.5, 10.8)	8.8 (7.9, 9.7)	10.2 (7.8, 13.3)	12.9 (9.1, 18.7)	11.1 (7.7, 16.2)	10.8 (9.1, 12.9)	11.6 (9.7, 13.6)	10.1 (7.5, 13.8)
Male	Discharge	26.6 (22.6, 31.3)	25.5 (22.6, 28.6)	20.1 (15.5, 25.1)	15.1 (11.3, 20.5)	20.8 (13.9, 30.3)	18 (14.5, 21.9)	24.9 (20.7, 30.7)	42.3 (32.9, 54.2)
Age group									
15-44	Death	10.7 (8, 14.2)	9.4 (7.1, 12.3)	11.1 (7.9, 16.3)	14.9 (9.6, 22.9)	14 (8.7, 22.5)	12.3 (8.8, 16.6)	13.5 (10.1, 18.7)	11.5 (7.8, 17.5)
15-44	Discharge	16.4 (13.4, 20)	15.8 (13.3, 19.2)	11.8 (8.9, 15.7)	9.3 (6.8, 12.9)	12.2 (8.4, 17.2)	10.9 (8.7, 13.8)	14.5 (11.7, 17.9)	28.1 (21.6, 36.9)
45-64	Death	10.9 (9.6, 12.5)	9.6 (8.5, 10.6)	11.3 (8.9, 15.1)	15.2 (10.6, 21.6)	14.2 (9.6, 21)	12.4 (10.3, 14.9)	13.7 (11.4, 16.3)	11.7 (8.9, 15.9)
45-64	Discharge	26.7 (22.8, 31.4)	25.7 (22.9, 29.6)	19.1 (15.2, 24)	15.1 (11.2, 20.2)	19.9 (13.8, 27.8)	17.7 (14.4, 21.5)	23.6 (19.8, 28.2)	45.7 (35, 59.1)
65-74	Death	9.4 (8.2, 10.9)	8.3 (7.3, 9.3)	9.8 (7.4, 13.4)	13.2 (9, 19.2)	12.3 (8.4, 18.3)	10.8 (8.8, 12.9)	11.9 (10.1, 14.2)	10.1 (7.6, 13.9)
65-74	Discharge	27.3 (22.4, 33.8)	26.3 (22.1, 31.2)	19.5 (15.1, 25.6)	15.4 (11.1, 21.7)	20.3 (14.1, 29)	18.1 (14.2, 22.7)	24.2 (19.9, 29.7)	46.7 (35, 62.6)
75+	Death	7 (5.9, 8.3)	6.1 (5, 7.2)	7.3 (5.3, 9.9)	10 (7, 14.8)	9.3 (6.2, 13.9)	8.1 (6.4, 9.8)	9 (7.3, 10.8)	7.5 (5.4, 10.6)
75+	Discharge	28.8 (21.5, 38.5)	27.7 (21.3, 36.3)	20.6 (14.7, 28.6)	16.2 (11.2, 24)	21.4 (13.9, 31.4)	19.1 (13.6, 26.1)	25.4 (18.9, 34.3)	49.2 (33.6, 68.7)
Region of residence									
London/South of England	Death	10.1 (8.8, 11.5)	9 (8.1, 10.1)	10.8 (8.2, 14.2)	13.7 (9.3, 19.6)	12 (7.8, 17.5)	11.4 (9.1, 14)	12.6 (10.3, 15.4)	11 (8, 14.9)
London/South of England	Discharge	25 (21.6, 28.9)	24.4 (20.9, 27.8)	18.8 (14.5, 24.6)	14.3 (10.2, 19.5)	19.7 (13.6, 28.6)	17.8 (13.9, 22.3)	23.2 (18.8, 28.5)	40.8 (31, 54.1)
Midlands and East of England	Death	8.7 (7.4, 10.2)	7.8 (6.8, 9.1)	9.3 (6.9, 12.5)	11.9 (7.9, 17.5)	10.4 (6.8, 15.3)	9.9 (8.2, 11.9)	10.9 (9, 13.3)	9.6 (6.9, 12.9)
Midlands and East of England	Discharge	23.7 (19.7, 28.4)	23.1 (19.2, 27.9)	17.8 (13.5, 23.1)	13.5 (9.8, 18.7)	18.7 (12.4, 27.8)	16.8 (13.4, 20.8)	22 (17.7, 26.8)	38.6 (29.6, 49.5)
North of England	Death	9.3 (7.9, 11.1)	8.4 (7.2, 9.9)	10 (7.5, 13.4)	12.7 (8.4, 18.4)	11.1 (7.4, 16.5)	10.6 (8.7, 12.6)	11.7 (9.8, 14.1)	10.3 (7.7, 14.2)
North of England	Discharge	23.7 (19.5, 29.4)	23.1 (19.7, 27.2)	17.8 (14, 23)	13.5 (9.7, 18.8)	18.7 (12.7, 26.7)	16.8 (13.9, 20.7)	22 (18.1, 26.8)	38.6 (29.8, 50.9)
Ethnicity			, , ,		, , ,		, ,	,	, , ,

Asian	Death	10.5 (8.8, 12.5)	9.4 (7.9, 10.9)	11.4 (8.3, 14.9)	13.9 (9.3, 20.2)	12.1 (8.3, 18.1)	12.1 (9.6, 15.2)	12.6 (10.3, 15.4)	10.7 (7.7, 14.7)
		. , ,	, , ,	, , ,		. , ,			, ,
Asian	Discharge	21.6 (16.9, 26.7)	21.1 (17.4, 25.4)	15.6 (11.3, 21.1)	11.3 (8, 16.2)	16.8 (11.6, 24.1)	15.3 (12, 19.8)	19.8 (15.2, 25.5)	33.7 (24.8, 46)
Black	Death	9.7 (7.9, 12)	8.7 (7, 10.5)	10.5 (7.7, 14.2)	12.9 (8.6, 19.1)	11.2 (7.4, 17)	11.2 (8.6, 14.5)	11.7 (8.9, 15.2)	9.9 (6.6, 13.7)
Black	Discharge	27.3 (20.5, 34.1)	26.7 (21.1, 34.3)	19.7 (14.1, 27.9)	14.3 (9.7, 20.2)	21.2 (14.2, 31.2)	19.3 (14.3, 26.4)	25 (18.4, 33.9)	42.6 (29.3, 61.3)
Mixed/Other	Death	11.2 (8.5, 14.6)	10 (7.5, 13.2)	12.1 (8.7, 16.7)	14.7 (9.5, 23)	12.9 (8.3, 19.4)	12.9 (9.4, 17.4)	13.4 (9.9, 18.1)	11.4 (7.6, 16.7)
Mixed/Other	Discharge	29.6 (22.2, 39.2)	29 (22.7, 37.8)	21.4 (15, 29.9)	15.6 (10.7, 22.1)	23.1 (14.7, 34.7)	21 (15.2, 28.1)	27.2 (20.1, 36.7)	46.3 (32, 65.4)
White	Death	9 (8, 10.3)	8 (7.1, 9.1)	9.8 (7.5, 12.7)	12 (8.1, 17.6)	10.4 (7.3, 15.1)	10.5 (8.7, 12.4)	10.9 (9, 12.9)	9.2 (6.8, 12.6)
White	Discharge	24 (20.3, 28)	23.5 (20.4, 26.8)	17.3 (13.6, 22.1)	12.6 (9.2, 17.5)	18.7 (13.2, 26.2)	17 (13.8, 20.7)	22 (18.1, 27.1)	37.5 (28.1, 48.5)
Number of									
comorbidities									
0	Death	11.1 (9.5, 13)	10.1 (8.7, 11.5)	11.9 (8.7, 15.8)	14.9 (10, 20.8)	13.1 (8.8, 18.8)	12.3 (10, 14.8)	13.3 (11, 15.8)	11.3 (8.2, 15.1)
0	Discharge	26.1 (21.8, 31.6)	25.8 (21.9, 29.8)	20.4 (15.9, 26.4)	15.1 (10.6, 21.2)	20.9 (14.2, 29.3)	18.2 (14.7, 22.2)	24.6 (19.8, 29.6)	42.9 (33.2, 57.6)
1	Death	10.3 (8.7, 12.4)	9.3 (8, 10.8)	11 (8.3, 14.5)	13.7 (9.3, 19.7)	12.1 (8, 17.4)	11.3 (9.3, 13.9)	12.3 (9.9, 14.9)	10.4 (7.7, 14.2)
1	Discharge	20.7 (17.4, 24.8)	20.5 (17.4, 24.1)	16.2 (12.6, 20.8)	12 (8.6, 16.6)	16.6 (11.2, 24.4)	14.4 (11.6, 17.6)	19.5 (15.9, 23.7)	34 (26.1, 45.4)
2	Death	8.6 (7.4, 10.2)	7.8 (6.6, 9.2)	9.3 (6.9, 12.2)	11.7 (7.7, 16.8)	10.3 (6.8, 14.9)	9.6 (7.7, 11.6)	10.4 (8.5, 12.5)	8.8 (6.5, 12.2)
2	Discharge	23.3 (18.8, 29.3)	23.1 (19.4, 27.6)	18.2 (13.7, 23.5)	13.5 (9.9, 18.7)	18.7 (13, 27.1)	16.2 (13.1, 20.4)	22 (17.3, 27.3)	38.3 (28.9, 50.3)
3+	Death	8.7 (7.5, 10.1)	7.8 (6.9, 9)	9.4 (7, 12.5)	11.8 (7.9, 17)	10.4 (7, 14.8)	9.7 (8.1, 11.4)	10.5 (8.6, 12.5)	8.9 (6.5, 11.9)
3+	Discharge	26.2 (22.2, 32)	26 (22.3, 30.2)	20.5 (15.6, 26.3)	15.2 (11, 21.5)	21.1 (14.8, 30.5)	18.3 (14.7, 22.9)	24.7 (20.2, 30.2)	43.1 (32.5, 59.1)

Supplementary table 8: Estimated odds ratios and 95% confidence intervals for outcomes from hospital admission, by baseline characteristic/month of admission

Group	Transition	Odds ratio
Month of admission (ref. Mar)		
Apr	Death	1.3 (1.1, 1.5)
May	Death	1.6 (1.3, 2)
Jun/Jul/Aug	Death	0.8 (0.6, 1.1)
Sep	Death	0.7 (0.5, 0.9)
Oct	Death	0.8 (0.7, 1)
Nov	Death	1 (0.8, 1.1)
Dec	Death	1.3 (1.1, 1.6)
Sex (ref. Female)		
Male	Death	0.6 (0.6, 0.7)
Age group (ref. 15-45)		
45-64	Death	2.3 (1, 4.9)
65-74	Death	8.2 (3.8, 18)
75+	Death	71.1 (32.7, 154.4)
Region of residence (ref. London/South of England)		
Midlands and East of England	Death	1.3 (1, 1.7)
North of England	Death	0.8 (0.6, 1.1)
Ethnicity (ref. Asian)		

Black	Death	1.2 (0.8, 1.8)
Mixed/Other	Death	0.6 (0.3, 1.1)
White	Death	2.1 (1.5, 3)
Number of comorbidities (ref. 0 comorbidities)		
1 comorbidity	Death	1.4 (0.9, 2.1)
2 comorbidities	Death	2.3 (1.5, 3.5)
3+ comorbidities	Death	5.2 (3.6, 7.5)
Month of admission (ref. Mar)		
Apr	Discharge	1.4 (1.2, 1.6)
May	Discharge	2.8 (2.3, 3.4)
Jun/Jul/Aug	Discharge	3 (2.4, 3.9)
Sep	Discharge	1.1 (0.8, 1.5)
Oct	Discharge	1.2 (1, 1.5)
Nov	Discharge	1.4 (1.2, 1.7)
Dec	Discharge	1.6 (1.3, 1.9)
Sex (ref. Female)		
Male	Discharge	0.5 (0.5, 0.6)
Age group (ref. 15-45)		
45-64	Discharge	0.5 (0.3, 0.6)
65-74	Discharge	0.5 (0.3, 0.7)
75+	Discharge	1.5 (1, 2.2)
Region of residence (ref. London/South of England)		
Midlands and East of England	Discharge	0.9 (0.7, 1.1)
North of England	Discharge	0.7 (0.6, 1)
Ethnicity (ref. Asian)		
Black	Discharge	1.2 (0.9, 1.8)
Mixed/Other	Discharge	1 (0.6, 1.6)
White	Discharge	1.5 (1.1, 1.9)
Number of comorbidities (ref. 0 comorbidities)		
1 comorbidity	Discharge	0.7 (0.5, 1)
2 comorbidities	Discharge	0.8 (0.6, 1.1)
3+ comorbidities	Discharge	1 (0.7, 1.3)

Supplementary table 9: Estimated odds ratios and 95% confidence intervals for outcomes from ICU admission, by baseline characteristic/month of admission

Group	Transition	Odds ratio
Month of admission (ref. Mar)		
Apr	Discharge	1 (0.8, 1.3)
May	Discharge	2 (1.3, 3)

Jun/Jul/Aug	Discharge	2.8 (1.7, 4.9)
Sep	Discharge	1.8 (1, 3.1)
Oct	Discharge	1.3 (1, 1.8)
Nov	Discharge	1.5 (1.1, 2.1)
Dec	Discharge	2.5 (1.6, 3.8)
Sex (ref. Female)		
Male	Discharge	0.4 (0.3, 0.7)
Age group (ref. 15-45)		
45-64	Discharge	0.4 (0.2, 0.7)
65-74	Discharge	0.2 (0.1, 0.3)
75+	Discharge	0.1 (0, 0.2)
Region of residence (ref. London/South of England)		
Midlands and East of England	Discharge	0.7 (0.4, 1)
North of England	Discharge	1 (0.6, 1.6)
Ethnicity (ref. Asian)		
Black	Discharge	1.2 (0.8, 1.7)
Mixed/Other	Discharge	1.8 (1.2, 2.8)
White	Discharge	1.2 (0.9, 1.5)
Number of comorbidities (ref. 0 comorbidities)		
1 comorbidity	Discharge	1 (0.6, 1.6)
2 comorbidities	Discharge	0.5 (0.3, 0.9)
3+ comorbidities	Discharge	0.7 (0.4, 1.2)

Supplementary table 10: Estimated odds ratios and 95% confidence intervals for outcomes from hospital admission, by baseline characteristic and month of admission

Group	Transition	Apr	May	Jun/Jul/Aug	September	October	November	December
Age group (ref. 15-45,								
Mar)								
45-64	Death	0.9 (0.4, 2.5)	1.3 (0.2, 7.7)	0.7 (0.1, 5.4)	0.9 (0.1, 12.9)	1.1 (0.2, 6.4)	1.6 (0.3, 8.3)	0.9 (0.2, 4.2)
65-74	Death	1.2 (0.4, 3.1)	1.8 (0.3, 11.1)	1.4 (0.2, 10)	1.3 (0.1, 17.8)	1.1 (0.2, 6.7)	1.4 (0.3, 7)	1.6 (0.3, 7.3)
75+	Death	1.8 (0.7, 4.9)	1.3 (0.2, 8)	1.1 (0.2, 7.5)	0.9 (0.1, 11.9)	0.9 (0.2, 5.5)	1.2 (0.2, 6.1)	1.9 (0.4, 8.6)
Region of residence								
(ref. London/South of								
England, Mar)								
Midlands and East of England	Death	1.7 (1.2, 2.4)	1.5 (0.9, 2.7)	1.3 (0.6, 3.1)	0.8 (0.2, 2.7)	0.5 (0.2, 0.9)	1.1 (0.6, 1.8)	1.3 (0.8, 2.2)

North of England	Death	1.3 (0.9, 1.9)	1.6 (0.9, 2.8)	2.2 (0.9, 5.4)	1 (0.3, 3)	1.1 (0.5, 2.1)	1.4 (0.8, 2.4)	1.1 (0.6, 1.9)
Ethnicity (ref. Asian,								
Mar)								
Black	Death	1 (0.5, 1.7)	0.3 (0.1, 1.3)	0.4 (0, 8.3)	0.6 (0.1, 5.3)	1.1 (0.2, 5.7)	2.9 (0.7, 12.1)	1.6 (0.4, 7.2)
Mixed/Other	Death	1 (0.5, 2.2)	2 (0.5, 8.5)	0.6 (0, 38.2)	1.3 (0.1, 14.2)	0.6 (0.1, 2.9)	0.6 (0.1, 3.1)	0.6 (0.1, 3.4)
White	Death	1.6 (1, 2.4)	2.1 (0.9, 5.2)	2.1 (0.7, 6.4)	0.9 (0.3, 2.6)	0.7 (0.4, 1.3)	1.7 (0.8, 3.3)	1.6 (0.7, 3.5)
Number of								
comorbidities (ref. 0 comorbidities, Mar)								
1 comorbidity	Death	1.3 (0.8, 2.2)	0.8 (0.4, 1.8)	0.8 (0.2, 2.5)	2.1 (0.6, 7.5)	1.1 (0.5, 2.2)	1.1 (0.6, 2.2)	1.5 (0.8, 3)
2 comorbidities	Death	1.4 (0.9, 2.3)	0.9 (0.4, 2)	1.3 (0.4, 4.1)	1 (0.3, 3.3)	1 (0.5, 2)	1.2 (0.6, 2.3)	1.2 (0.6, 2.4)
3+ comorbidities	Death	1.1 (0.7, 1.8)	1 (0.5, 2.1)	0.6 (0.2, 1.5)	0.6 (0.2, 1.7)	0.9 (0.5, 1.8)	1 (0.5, 1.7)	1.1 (0.6, 2.1)
Age group (ref. 15-45, Mar)								
45-64	Discharge	1.1 (0.7, 1.7)	0.6 (0.3, 1.2)	1.2 (0.6, 2.5)	0.7 (0.3, 1.6)	0.8 (0.4, 1.4)	0.7 (0.4, 1.3)	1.4 (0.8, 2.3)
65-74	Discharge	1.3 (0.8, 2)	1 (0.4, 2.1)	2 (0.9, 4.6)	0.7 (0.3, 1.9)	0.6 (0.3, 1.2)	0.7 (0.4, 1.2)	1.8 (1, 3.2)
75+	Discharge	2.6 (1.5, 4.3)	0.9 (0.4, 2)	1.4 (0.6, 3.4)	0.5 (0.2, 1.5)	0.7 (0.4, 1.4)	0.7 (0.4, 1.4)	2.2 (1.1, 4.2)
Region of residence (ref. London/South of England, Mar)								
Midlands and East of England	Discharge	1.3 (1, 1.8)	1.1 (0.6, 1.7)	0.5 (0.3, 0.9)	1.3 (0.5, 3.7)	0.9 (0.5, 1.6)	1.2 (0.8, 1.9)	1.3 (0.8, 2)
North of England	Discharge	0.9 (0.7, 1.3)	1.2 (0.7, 2)	0.7 (0.3, 1.4)	0.9 (0.3, 2.2)	1 (0.6, 1.9)	0.8 (0.5, 1.3)	0.6 (0.4, 1)
Ethnicity (ref. Asian, Mar)								
Black	Discharge	1.2 (0.8, 2)	0.4 (0.2, 1)	2 (0.5, 7.6)	0.4 (0.1, 1.9)	1.4 (0.4, 5.4)	0.8 (0.2, 2.8)	1.1 (0.3, 3.3)
Mixed/Other	Discharge	1 (0.6, 1.8)	0.8 (0.3, 2.3)	2.3 (0.4, 12.2)	1 (0.2, 5.1)	0.6 (0.2, 1.8)	0.7 (0.3, 1.7)	0.8 (0.3, 2)
White	Discharge	1.4 (1, 2)	0.8 (0.4, 1.5)	0.8 (0.4, 1.7)	0.7 (0.3, 1.6)	1 (0.6, 1.7)	1.1 (0.6, 1.7)	0.8 (0.4, 1.4)
Number of comorbidities (ref. 0 comorbidities, Mar)								
1 comorbidity	Discharge	1.4 (1, 2.1)	0.9 (0.5, 1.7)	1 (0.4, 2.2)	1.5 (0.6, 3.8)	1.1 (0.7, 1.8)	1 (0.6, 1.6)	1.5 (0.9, 2.5)
2 comorbidities	Discharge	1.4 (1, 2.1)	1 (0.6, 1.9)	0.8 (0.4, 1.9)	0.6 (0.2, 1.4)	0.9 (0.5, 1.5)	1 (0.6, 1.7)	1.1 (0.6, 1.8)
3+ comorbidities	Discharge	1.7 (1.2, 2.4)	1.4 (0.8, 2.5)	0.6 (0.3, 1.2)	0.5 (0.2, 1)	0.9 (0.6, 1.4)	1 (0.6, 1.5)	1.5 (0.9, 2.4)

Supplementary table 11: Estimated odds ratios and 95% confidence intervals for outcomes from ICU admission, by baseline characteristic and month of admission

Group	Transition	Apr	May	Jun/Jul/Aug	September	October	November	December
Sex (ref. Female, Mar)								
Male	Discharge	1.6 (1, 2.8)	1.5 (0.6, 3.7)	1.2 (0.4, 4)	1 (0.3, 3.5)	0.8 (0.4, 1.7)	1.7 (0.9, 3.2)	1.9 (0.8, 4.7)
Age group (ref. 15-45, Mar)								
45-64	Discharge	0.5 (0.2, 1.4)	1 (0.1, 7.8)	1.6 (0.2, 13.5)	3.2 (0.1, 70.3)	1.4 (0.3, 6.6)	0.9 (0.2, 3.8)	0.9 (0.2, 4.3)
65-74	Discharge	0.6 (0.2, 1.7)	1.5 (0.2, 12.8)	0.9 (0.1, 8.5)	0.6 (0, 12.2)	1 (0.2, 5.1)	1.1 (0.2, 5.1)	1.8 (0.3, 9.5)
75+	Discharge	0.7 (0.2, 2.2)	1.4 (0.1, 12.8)	1.2 (0.1, 12.7)	1.1 (0, 25.3)	0.6 (0.1, 3.7)	0.8 (0.2, 4.2)	0.6 (0.1, 3.6)
Region of residence								
(ref. London/South of								
England, Mar)								
Midlands and East of England	Discharge	1 (0.6, 1.8)	1 (0.4, 2.7)	1.7 (0.4, 7.3)	1.3 (0.1, 11.8)	1.2 (0.3, 3.9)	0.5 (0.2, 1.3)	1 (0.4, 2.7)
North of England	Discharge	1.7 (0.9, 3.1)	1.8 (0.6, 5.3)	1.1 (0.3, 5)	1.1 (0.1, 8.6)	1.6 (0.5, 5.3)	0.6 (0.3, 1.6)	1.2 (0.4, 3.7)
Number of comorbidities (ref. 0 comorbidities, Mar)								
1 comorbidity	Discharge	0.8 (0.4, 1.5)	0.7 (0.2, 2.5)	1.5 (0.2, 11)	0.9 (0.1, 5.5)	1.3 (0.5, 3.5)	1 (0.4, 2.4)	0.9 (0.3, 2.8)
2 comorbidities	Discharge	1.3 (0.6, 2.6)	1.4 (0.4, 5.4)	3.5 (0.4, 29.6)	1.2 (0.2, 6.7)	1.9 (0.7, 4.8)	1.3 (0.5, 3.3)	2.6 (0.8, 9.1)
3+ comorbidities	Discharge	0.8 (0.4, 1.6)	0.9 (0.3, 3.1)	1 (0.2, 5.3)	1.1 (0.2, 5.2)	1.4 (0.6, 3.3)	1.2 (0.5, 2.7)	0.6 (0.2, 1.6)

Supplementary table 12: Expected time ratios and 95% confidence intervals for outcomes from hospital admission, by baseline characteristic/month of admission

Group	Transition	Expected time ratio
Month of admission (ref. Mar)		
Apr	Death	1 (0.9, 1.1)
May	Death	1.2 (1.1, 1.3)
Jun/Jul/Aug	Death	1.4 (1.2, 1.6)
Sep	Death	1.3 (1.1, 1.5)
Oct	Death	1.3 (1.1, 1.4)
Nov	Death	1.3 (1.2, 1.4)
Dec	Death	1.6 (1.4, 1.8)

Sex (ref. Female)		
Male	Death	1 (1, 1.1)
Age group (ref. 15-45)		
45-64	Death	1 (0.8, 1.3)
65-74	Death	1 (0.7, 1.2)
75+	Death	0.9 (0.7, 1.2)
Region of residence (ref. London/South of England)		
Midlands and East of England	Death	1 (0.9, 1.1)
North of England	Death	1 (0.9, 1.1)
Ethnicity (ref. Asian)		
Black	Death	1 (0.9, 1.1)
Mixed/Other	Death	1.1 (0.9, 1.4)
White	Death	1.1 (1, 1.2)
Number of comorbidities (ref. 0 comorbidities)		
1 comorbidity	Death	1 (0.9, 1.1)
2 comorbidities	Death	1 (0.9, 1.1)
3+ comorbidities	Death	0.9 (0.8, 1)
Month of admission (ref. Mar)		
Apr	Discharge	1 (0.9, 1.1)
May	Discharge	0.8 (0.7, 0.9)
Jun/Jul/Aug	Discharge	0.7 (0.6, 0.7)
Sep	Discharge	1.2 (1, 1.4)
Oct	Discharge	1.7 (1.5, 1.9)
Nov	Discharge	1.2 (1.1, 1.3)
Dec	Discharge	1.5 (1.4, 1.7)
Sex (ref. Female)		
Male	Discharge	1.1 (1, 1.2)
Age group (ref. 15-45)		
45-64	Discharge	1.7 (1.6, 1.8)
65-74	Discharge	2.4 (2.2, 2.6)
75+	Discharge	3.7 (3.5, 4)
Region of residence (ref. London/South of England)		
Midlands and East of England	Discharge	1.3 (1.2, 1.3)
North of England	Discharge	1.7 (1.6, 1.9)
Ethnicity (ref. Asian)		
Black	Discharge	1.1 (1, 1.3)

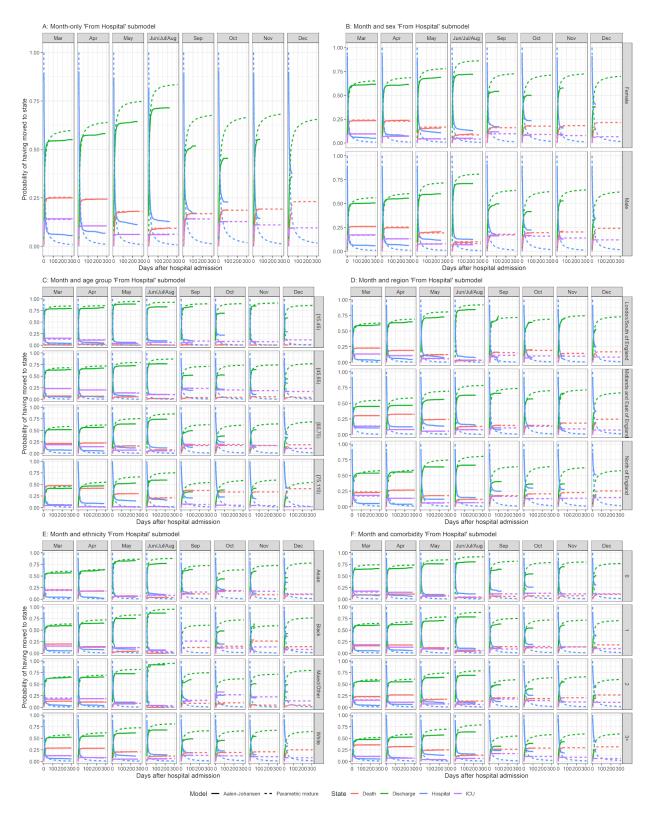
Mixed/Other	Discharge	1.1 (0.9, 1.3)
White	Discharge	1.6 (1.5, 1.7)
Number of comorbidities (ref. 0 comorbidities)		
1 comorbidity	Discharge	1.3 (1.2, 1.4)
2 comorbidities	Discharge	1.7 (1.6, 1.8)
3+ comorbidities	Discharge	2.1 (2, 2.3)
Month of admission (ref. Mar)		
Apr	ICU	1 (0.9, 1.2)
May	ICU	1.2 (1, 1.4)
Jun/Jul/Aug	ICU	1 (0.8, 1.2)
Sep	ICU	1.2 (0.9, 1.5)
Oct	ICU	1 (0.9, 1.2)
Nov	ICU	0.9 (0.8, 1)
Dec	ICU	0.7 (0.6, 0.9)
Sex (ref. Female)		
Male	ICU	1 (0.9, 1.1)
Age group (ref. 15-45)		
45-64	ICU	1.2 (1, 1.4)
65-74	ICU	1.2 (1, 1.4)
75+	ICU	1.3 (1.1, 1.6)
Region of residence (ref. London/South of England)		
Midlands and East of England	ICU	1.2 (1.1, 1.4)
North of England	ICU	1.1 (0.9, 1.2)
Ethnicity (ref. Asian)		
Black	ICU	1 (0.8, 1.2)
Mixed/Other	ICU	0.8 (0.7, 1)
White	ICU	1.1 (1, 1.2)
Number of comorbidities (ref. 0 comorbidities)		
1 comorbidity	ICU	1 (0.9, 1.1)
2 comorbidities	ICU	1 (0.9, 1.2)
3+ comorbidities	ICU	1.1 (1, 1.2)

Supplementary table 13: Expected time ratios and 95% confidence intervals for outcomes from ICU admission, by baseline characteristic/month of admission

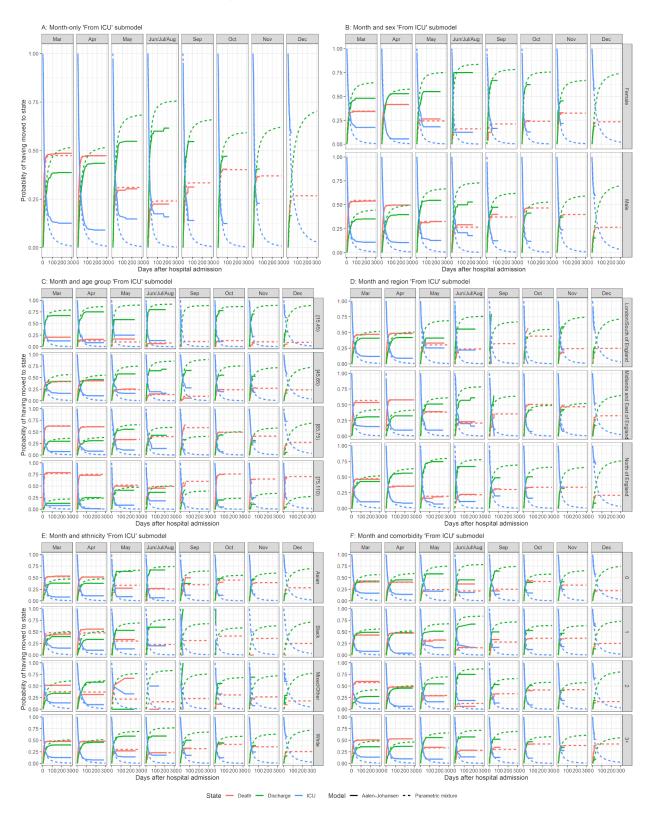
Group	Transition	Expected time ratio
Month of admission (ref. Mar)		
Apr	Death	0.9 (0.8, 1.1)
May	Death	1.1 (0.8, 1.3)
Jun/Jul/Aug	Death	1.3 (0.9, 1.7)
Sep	Death	1.1 (0.8, 1.5)
Oct	Death	1.1 (0.9, 1.3)
Nov	Death	1.2 (1, 1.4)
Dec	Death	1 (0.8, 1.3)
Sex (ref. Female)		
Male	Death	1.1 (1, 1.2)
Age group (ref. 15-45)		
45-64	Death	1 (0.8, 1.3)
65-74	Death	0.9 (0.7, 1.1)
75+	Death	0.7 (0.6, 0.9)
Region of residence (ref. London/South of		
England)		
Midlands and East of England	Death	0.9 (0.8, 1)
North of England	Death	0.9 (0.8, 1.1)
Black	Death	0.9 (0.8, 1.1)
Mixed/Other	Death	1.1 (0.8, 1.3)
White	Death	0.9 (0.8, 1)
Number of comorbidities (ref. 0 comorbidities)		
1 comorbidity	Death	0.9 (0.8, 1.1)
2 comorbidities	Death	0.8 (0.7, 0.9)
3+ comorbidities	Death	0.8 (0.7, 0.9)
Month of admission (ref. Mar)		
Apr	Discharge	1 (0.8, 1.2)
May	Discharge	0.8 (0.6, 1)
Jun/Jul/Aug	Discharge	0.6 (0.4, 0.8)
Sep	Discharge	0.8 (0.5, 1.1)
Oct	Discharge	0.7 (0.5, 0.9)
Nov	Discharge	0.9 (0.7, 1.2)
Dec	Discharge	1.6 (1.2, 2.1)
Sex (ref. Female)		
Male	Discharge	1.2 (1.1, 1.4)
Age group (ref. 15-45)		
45-64	Discharge	1.6 (1.4, 1.9)

65-74	Discharge	1.7 (1.3, 2.1)
75+	Discharge	1.8 (1.3, 2.4)
Region of residence (ref. London/South of England)	_	
Midlands and East of England	Discharge	0.9 (0.8, 1.1)
North of England	Discharge	0.9 (0.8, 1.1)
Ethnicity (ref. Asian)	J	
Black	Discharge	1.3 (0.9, 1.7)
Mixed/Other	Discharge	1.4 (1, 1.9)
White	Discharge	1.1 (0.9, 1.4)
Number of comorbidities (ref. 0 comorbidities)		
1 comorbidity	Discharge	0.8 (0.7, 1)
2 comorbidities	Discharge	0.9 (0.7, 1.1)
3+ comorbidities	Discharge	1 (0.8, 1.2)

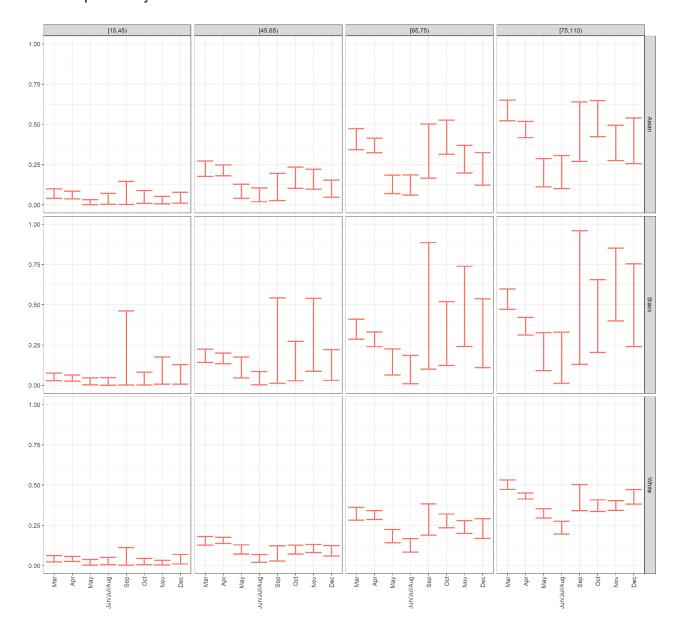
Supplementary Figure 1: Goodness of fit for "From Hospital' sub-model, by month of admission (panel A), and sex (panel B), age group (panel C), region of residence (panel D), ethnicity (panel E), and number of comorbidities (panel F). Solid lines are Aalen-Johansen cumulative incidence curves, dotted lines are derived from the parametric mixture model.



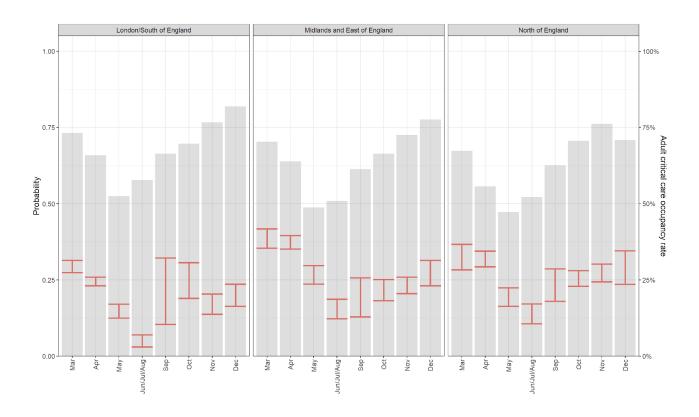
Supplementary Figure 2: Goodness of fit for "From ICU" sub-model, by month of admission (panel A), and sex (panel B), age group (panel C), region of residence (panel D), ethnicity (panel E), and number of comorbidities (panel F). Solid lines are Aalen-Johansen cumulative incidence curves, dotted lines are derived from the parametric mixture model.



Supplementary Figure 3: Estimated hospitalised case-fatality risk (HFR) averaged over ICU and non-ICU admission. Error bars are 95% confidence intervals to represent uncertainty in the estimated probability.



Supplementary Figure 4: Estimated hospitalised case-fatality risk (HFR) averaged over ICU and non-ICU admission, by month of admission, region of residence (line range) and regional adult critical care occupancy rate¹ (bar).



¹Data on regional adult critical care occupancy rate accessed from:

https://www.england.nhs.uk/statistics/statistical-work-areas/uec-sitrep/urgent-and-emergency-care-daily-situation-reports-2020-21/