

Characterisation of in-hospital complications associated with COVID-19 using the ISARIC WHO Clinical Characterisation Protocol UK: A prospective, multicentre cohort study.

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Evidence before this study

Most COVID-19 studies have focused on mortality and respiratory support outcomes, while systematic characterisation of other complications has not yet been undertaken. Characterising the burden of complications is important for healthcare system preparedness for further waves of infection, determining future population morbidity, understanding the full repercussions of COVID-19 for society, and for informing future research and clinical guidelines. The current literature is comprised of several small cohort or case-control studies which focus on specific organ systems or conditions. There is a lack of prospective systematically collected data describing the in-hospital complications of COVID-19.

Added value of this study

Hospitalised patients with COVID-19 frequently had complications, even in younger age groups and those with few pre-existing comorbidities. Occurrence of complications was associated with a significantly reduced ability to self-care at discharge, which was seen in all age and comorbidity groups. While patients under the age of 50 years are at lower risk of mortality, we found high rates of complications across all age groups.

Implications of all the available evidence

In patients admitted to hospital with COVID-19, there is a burden of immediate complications affecting all age groups. Many of the complications identified are likely to have important long-term effects. Healthcare systems and policy makers should plan for increases in population morbidity arising from COVID-19 and its subsequent complications. As complications following COVID-19 are common across all age groups and comorbidities, public health messaging around the risk COVID-19 poses to younger otherwise healthy people should be considered alongside vaccine prioritisation. Further studies are required to understand the medium to long-term effects of COVID-19 and how immediate complications may lead to lasting morbidity.

Abstract

Background

COVID-19 is a multi-system disease and patients who survive may experience in-hospital complications. These complications are likely to have important short and long-term impacts for patients, healthcare utilisation, healthcare system preparedness, and society amidst the ongoing COVID-19 pandemic. The aim was to characterise the extent and impact of COVID-19 complications, particularly in those who did not die.

Methods

A multicentre, prospective cohort study in 302 UK healthcare facilities of adults hospitalised with COVID-19 between 17th January to 4th August 2020. Complications were defined as organ specific diagnoses occurring alone or in addition to any hallmarks of COVID-19 illness. Outcomes included death, critical care use, and functional outcomes. We used multilevel logistic regression and survival models to explore associations between comorbidities, in-hospital complications, and death.

Results

Of patients admitted to hospital for management of COVID-19, 49.7% (36 367/73 197) experienced at least one complication. Complications were most common in males, those aged 30 and over, and in patients with comorbidities. Renal (24.3%, 17 752/73 197), complex respiratory 18.4% (13 486/73 197), and systemic (16.3%, 11 895/73 197) complications were most frequent. Cardiovascular (12.3%, 8973/73 197), neurological (4.3%, 3115/73 197), and gastrointestinal (including liver; 10.8%, 7901/73 197) complications were also reported. The presence of any complication was associated with significantly worse survival (adjusted HR 1.74, 95% CI 1.64 to 1.84). Reduced ability to self-care at discharge was significantly greater in patients who experienced a complication (25.2%, 95% CI 24.5 to 25.9%) compared with those who did not (11.9%, 95% CI 11.5 to 12.3%).

Conclusions

Complications and worse functional outcomes in patients admitted to hospital with COVID-19 are high, even in young, previously healthy individuals. Acute complications are associated with reduced ability to self-care at discharge, with neurological complications being associated with the worst functional outcomes. COVID-19 complications are likely to cause significant strain on

health and social care in the coming years. These data will help in the design and provision of services aimed at the post-hospitalisation care of patients with COVID-19.

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Introduction

Many people across the world have been hospitalised with coronavirus disease 2019 (COVID-19) following infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Current evidence has established these patients have high mortality rates (26%) and up to 17% of patients admitted to hospital will require ventilatory support and critical care¹. Several case reports, cross-sectional, and case-control studies have described the presence of non-respiratory complications in COVID-19 and suggest that these are likely to be associated with poor outcomes²⁻⁴.

Understanding the possible complications of COVID-19 is important for patient management and for provision in healthcare systems. For patients, information around in-hospital complication rates are important for decision making about treatment, long-term planning, possible resumption of normal activity and, more recently, vaccination. For healthcare systems, these data are vital to inform immediate preparedness measures (i.e., allocation of resources, equipment, and staffing) but also for long-term planning of healthcare delivery to a population which may have incurred additional morbidity due to COVID-19.

A substantial proportion of patients with COVID-19 go on to develop critical illness and require organ support. Within the critical care literature, it is widely recognised that surviving critical illness is accompanied by a substantial burden of additional physical and mental health morbidity that mortality outcomes cannot measure^{5,6}. Mortality has been widely used as an outcome in epidemiological studies and randomised controlled trials studying patients with SARS-CoV-2, which fails to capture the immediate short-term health issues experienced by survivors, including in-hospital complications and functional outcomes. In other non-SARS-CoV-2 viral illnesses, for example influenza, short-term complications such as myocardial infarction, acute kidney injury (AKI) and stroke, are common and may cause greater morbidity than the initial infection itself⁶⁻¹⁰. Understanding who develops short-term complications may also allow clinicians and researchers to develop care pathways and interventions to mitigate the impact of complications.

As many patients with COVID-19 are critically unwell, identifying the burden of short-term morbidity may be useful to understand the long-term burden on healthcare systems and the society for those who survive COVID-19.

We have previously characterised the clinical features of patients admitted to hospital with COVID-19 using the International Severe Acute Respiratory and emerging Infections Consortium (ISARIC) WHO Clinical Characterisation Protocol UK (CCP-UK) for Severe Emerging Infections. The aim of this study was to describe the short-term complications, beyond those associated with the presenting features of COVID-19 and severe acute respiratory infection.

Methods

The ISARIC WHO CCP-UK protocol was developed in 2009 and activated in response to the SARS-CoV-2 pandemic on 17th January 2020. This is an actively recruiting prospective cohort study recruiting across the United Kingdom. Study materials; including protocol, revision history, case report forms, study information and consent forms, are available online¹¹. Ethical approval was given by the South Central - Oxford C Research Ethics Committee in England (Ref: 13/SC/0149), and by the Scotland A Research Ethics Committee (Ref: 20/SS/0028). The study is reported in line with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Adult patients aged 19 years and over, who were admitted to hospital between 17th January 2020 to 4th August 2020 with confirmed or highly suspected SARS-CoV-2 infection leading to COVID-19 were included in this analysis, overall study recruitment is ongoing. Confirmation of SARS-CoV-2 was performed using reverse-transcriptase polymerase chain reaction (RT-PCR). Highly suspected cases were eligible for inclusion, given that SARS-CoV-2 was an emergent pathogen at time of protocol activation and laboratory confirmation was dependent on local availability of testing.

Data collected by research nurses and volunteer medical students were entered into a standardised electronic case report form within a secure Research Electronic Data Capture (REDCap) database¹². Multiple timepoints were captured, including admission, hospital stay days 1, 3, 9 and discharge or status at 28 days if not discharged. Participant characteristics including age, sex at birth, physiological parameters at presentation and comorbidities were also recorded. Comorbidities included asthma, chronic cardiac disease, chronic haematologic disease, chronic kidney disease, chronic neurological disease, chronic pulmonary disease, HIV/AIDS, history of malignancy, liver disease, clinician-defined obesity, rheumatologic disorders and smoking. Deprivation was calculated by mapping individual postcodes to their corresponding Index of Multiple Deprivation (IMD) using Office for National Statistics (ONS) postcode data. Using national data, we calculated deprivation quintiles, with the first quintile being least deprived and the fifth quintile the most deprived. For patients where postcodes were missing, the average IMD rank, weighted by population in each lower super output area for a given hospital catchment area was used.

Outcome definitions

The primary outcome of this study was the incidence of in-hospital complications, defined as organ specific diagnoses occurring alone or in addition to any hallmarks of COVID-19 illness. All complications were recorded so total morbidity could be described, not just those directly attributable to COVID-19. Although COVID-19 is a multisystem disease, severe respiratory infection was considered characteristic of COVID-19 and was not regarded as a complication. Data were collected on organ-specific complications including complex respiratory (bacterial pneumonia, acute respiratory distress syndrome (ARDS), empyema, pneumothorax, pleural effusion), neurological (meningitis, encephalitis, seizure, stroke), cardiovascular (thromboembolism, heart failure, myocarditis, endocarditis, arrhythmia, cardiomyopathy, myocardial ischaemia, cardiac arrest), acute kidney injury, gastrointestinal (acute liver injury, pancreatitis, gastrointestinal haemorrhage) and other systemic complications (coagulopathy, disseminated intravascular coagulation, anaemia, bloodstream infection). The presence of complications was extracted from routine clinical records by local investigators with the exceptions of bloodstream infection (BSI) and microbiologically confirmed bacterial pneumonia. These were defined based on recorded results from sputum, deep respiratory or blood cultures and restricted to instances where clinically significant organisms had been detected in the sample. Results considered to represent contamination or colonisation were excluded. Owing to the difficulties of obtaining lower respiratory tract samples to confirm bacterial pneumonia and the low positivity rates, we present both highly likely and suspected bacterial pneumonia in supplementary tables.

The existence of likely ARDS was described clinically or defined as one of the following combinations: receiving extracorporeal membrane oxygenation, being nursed in a prone position and receiving invasive mechanical ventilation, receiving mechanical ventilation and having a PF (PaO₂/FiO₂) ratio of 300 or less. For acute kidney injury and acute liver injury, we used laboratory measurements with internationally recognised grading systems to detect complications that may have been missed. Acute kidney injury was defined as a creatinine rise which corresponded to Kidney Disease Improving Global Outcomes (KDIGO) stage I or above definition¹³ (creatinine rise ≥ 1.5 x baseline value or by ≥ 26.5 $\mu\text{mol/L}$). Acute liver injury was defined as an international normalised ratio (INR) rise of 2.5 times or greater than the lowest entered value, or an INR of over 4.5 (in the absence of warfarin therapy), or an alanine aminotransferase (ALT) rise of greater than 10 times the lowest value, or an ALT over 150, or a bilirubin rise of greater than 15 or a bilirubin greater than 55 (in the absence of any pre-existing liver disease). In those who survived we also

captured information on whether self-care ability was the same or worse than before hospital admission at time of discharge.

Statistical analysis

Continuous data are presented as means alongside the standard deviation (SD) where the data are normally distributed and as medians alongside the 25th and 75th centiles for non-parametric data. Categorical data were summarised as frequencies and percentages. Differences between groups for continuous normally distributed data, were tested using Welch's T-test for two groups or analysis of variance (ANOVA) for where there were more than two groups. Non-parametric continuous data were tested using a Mann-Whitney U test for two groups or Kruskal-Wallis test for three or more groups. Differences across categorical data were tested using Chi-square with Fisher's exact used if cell counts were below five. Analysis of complication co-occurrence was done using the Jaccard similarity index and represented visually as heatmaps with dendrograms. We only included patients who had completed outcomes, with at least 2 months of follow-up. Where there was missing complication outcome data, but a discharge or death outcome available, we treated this as not having the given outcome to provide the most conservative effect. There were very low rates of missing data.

To explore if the number of complications and which specific complications were associated with mortality, complication variables were entered independently into Cox Proportional Hazards models. These data were described using Kaplan-Meier plots and modelled using Cox Proportional Hazards regression. Reported date of symptom onset was taken as day zero. Discharge from hospital was considered an absorbing state (once discharged, patients were considered no longer at risk of death), thus discharge did not compete with death.

To see whether complications were associated with increased severity, we used the 4C Mortality Score, quick sequential organ failure assessment (qSOFA) and National Early Warning Score 2 (NEWS2) on admission or time of symptom start to examine the relationship between severity and presence of any in-hospital complications¹⁴. We calculated the score for each adult patient in the dataset and plotted each score against the observed incidence of complications in each score group.

Multilevel logistic regression models were constructed to identify associations between patient characteristics (demographics and existing comorbidities) and the development of specific

complications. Explanatory variables of interest or for use in adjustment were included in these models. For all models (survival and logistic regression), clinically plausible variables were entered, and final models were selected based on clinical relevance guided by minimisation of the Akaike information criterion (AIC). Centre-level variation was accounted for using mixed-effects models which entered hospital as a random-effect and patient-level variables as fixed-effects. We conducted stratified analyses to focus on survivors and on those admitted to critical care. In-hospital complications are likely to have profound long-term consequences for those surviving COVID-19 and critical care survivors are likely to have had the most severe disease¹⁵. All statistical analyses were performed using R version 3.6.3 (R Foundation for Statistical Computing, Vienna, AUT) with the tidyverse, finalfit, survival, stringdist, janitor and Hmisc packages.

Role of the funding source

The study sponsors and funders had no role in the study design, collection, analysis, data interpretation or report writing. TMD, RA, RP, JKB, ABD, MGS and EMH had access to the raw data. The corresponding author had full access to all data and the final responsibility to submit for publication.

Results

Included patients

As of 4th August 2020, 80 388 patients were included in the CCP-UK study (figure 1). Of these, 75 276 were adults aged 19 years or over, 97.2% (73 197/75 276) had any complication outcome available for analysis. The overall mortality rate was 31.5% (23 092/73 197), and the overall complication rate was 49.7% (36 367/73 197 experienced at least one complication). In surviving patients, 43.5% (21 784/50 105) experienced at least one complication. Proportions of patients experiencing at least one complication were highest in age groups over 60 (table 1).

Incidence and patterns of complications

In adult patients with COVID-19, renal (24.3%, 17 752/73 197), complex respiratory 18.4% (13 486/73 197), cardiovascular 12.3% (8973/73 197), neurological 4.3% (3115/73 197), gastrointestinal (including liver) 10.8% (7901/73 197) and systemic complications 16.3% (11 895/73 197) were reported (table 1). Specific complications within each organ system were also reported, with AKI, ARDS, liver injury, anaemia and cardiac arrhythmia most commonly reported (supplement pp 1-2). The incidence of AKI increased with age and was most common in patients aged between 60 and 90 years of age, with men at greater risk. Patients with chronic kidney disease were at the highest risk of AKI, with 39.8% developing AKI (4785/12 182) versus 21.6% (11 962/55 458) in patients without chronic kidney disease. Cardiac complications increased with age and in patients with existing cardiac disease. In those with existing cardiac disease, 19.9% (4496/22 563) developed a cardiac complication compared to 8.9% (4077/45 563) in those without previous cardiac disease. In contrast, liver injury was most frequently seen in younger age groups under 60 years old, with the highest rates occurring in men. Liver injury was more common in patients with pre-existing moderate/severe liver disease (22.4%, 300/1340) compared to those without (6.2%, 4097/65 646). Overall, complications were similar across ethnicity groups, however patients in the black ethnic group had a significantly higher rate of acute kidney injury (33.1% 822/2480, compared to 24.0% in white patients 12 896/53 780, table 1). Obese patients were 1.6 times more likely to have respiratory complications (28.1%, 2059/7329 in obese versus 17.8%, 9498/53 415 in non-obese) and 1.3 times more likely to have renal complications (30.1%, 2208/7329 in obese versus 23.7%, 12 656/53 415 in non-obese, table 1).

Suspected bacterial pneumonia was the most common respiratory complication (supplement pp 3-4), but when the definition incorporated positive microbiological testing (highly likely bacterial

pneumonia), the incidence of highly likely bacterial pneumonia was lower. Acute kidney injury, ARDS, anaemia and liver injury were most likely to co-occur (figure 2A).

Predictors of developing complications

Experiencing at least one complication was common across all demographic groups, with the lowest rates in patients aged 19 to 29 with no comorbidity (21.2%, 178/839) and highest in the 60 to 69 age group in patients with two or more comorbidities (57.9%, 3340/5767; supplement pp 5-8). The incidence of complications rose with increasing age occurring in 38.9% (3 5962/9 249) in those aged 19 to 50 years and 51.3% (32 771/63 948, figure 2B) in those aged 50 years and older. The number of complications increased with number of pre-existing comorbidities, particularly in older individuals (figure 2B, supplement pp 5-8). Complications were higher in men than in women, and although men were more likely to experience complications at younger ages, men over 60 were most likely to experience a complication (aged under 60, 36.6% [2814/7689] in women and 48.8% [5179/10 609] in men; aged 60 and over, 48.2% [11 707/24 288] in women and 54.5% [16 579/30 416] in men; figure 2B; supplement pp 1-2). Young men without comorbidities were significantly more likely to experience complications than women without comorbidities (28.4% [94/331] in men aged 19 to 29 and 16.6% [84/505] in women aged 19 to 29; figure 2B). When we stratified by mortality, complications occurred more frequently patients who died (63.2%, 14 583/23 092), but were still commonly experienced by survivors (43.5%, 21 784/50 105, supplement pp 9-10) and there were direct relationships between worse survival and increasing numbers of complications (figure 3A).

After adjusting for age, sex, deprivation, comorbidities and centre, increasing age and male sex were significant independent predictors for developing any complication and for all organ specific complications except for gastrointestinal and liver, where younger patients were more likely to have complications (supplement pp 32-34). Those with pre-existing comorbidities that affected a specific organ system were at higher risk of developing a complication affecting the same organ (supplement pp 35-36).

Survival and in-hospital complications

Complications were more common in those requiring respiratory support and were highest in patients who received critical care (82.4%, 8267/10 034), or who received invasive mechanical ventilation (91.7%, 5619/6122, table 2). The presence and number of complications was significantly associated with worse in-hospital survival (figure 3A). Following adjustment for age,

sex, deprivation, and hospital, experiencing any complication was significantly associated with poorer overall survival (figure 3B). Cardiovascular (HR 1.98, 95%CI 1.85 to 2.11) and complex respiratory complications (HR 2.15, 95%CI 2.04 to 2.27) were most strongly associated with worse outcomes. After adjustment for age, sex and deprivation, patients experiencing an acute kidney injury were 4 times more likely to be admitted to critical care and those with respiratory complications were 13 times more likely to be admitted to critical care (figure 3C).

Severity and symptoms

Physiology-based early warning scores and the ISARIC 4C Mortality Score using parameters at hospital admission were associated with the occurrence of complications in survivors. Higher 4C Mortality Score on admission corresponded with an increased probability of at least one complication (figure 4A). Similarly, higher NEWS2 (figure 4B) and qSOFA scores on admission (figure 4C) were associated with an increased probability of one or more complications. The number of symptoms on admission did not appear to be related to the incidence of complications (figure 4D).

Functional outcomes in COVID-19 survivors

On discharge from hospital, 17.5% (6758/38 627) of patients had worse ability to self-care than when they were admitted (figure 5A). This increased with age, male sex and in those who received critical care support (figure 5A and 5B). Experiencing a complication was independently associated with an increased risk of worse ability to self-care after discharge after adjusting for age, sex, deprivation and hospital (adjusted OR 2.47, 95% CI 2.33 to 2.61, figure 5C). Neurological complications had the strongest associations with worse functional outcome (adjusted OR 4.08, 95% CI 3.59 to 4.63, figure 5C).

Discussion

Hospitalisation with COVID-19 is associated with high rates of morbidity in adults. Half of adult patients had one or more complications, which were more likely in patients who required critical care. Adult survivors of COVID-19 who had suffered at least one complication had a lower ability to self-care on discharge from hospital. The effect of complications on the ability to self-care was most profound in younger patients under the age of 50 years. Unlike mortality, which has a strong relationship with age and presence of comorbidities in COVID-19, we found that complication rates were high in every age group. Men were significantly more likely to develop complications and at an earlier age. There were also important differences in complications across different ethnic groups.

Whilst complication rates were highest in patients who died, those who survived also had a significant burden of complications. The most common complications in our data were acute kidney injury, respiratory and systemic complications. Although our study only looked at complications during the first admission for COVID-19, many of the complications we identified as being common are associated with significant long-term morbidity. Acute kidney injury is one of the most common complications we identified and is associated with increased long-term hazards of mortality, requirement for dialysis and an increase in cardiovascular events¹⁶⁻¹⁸. In addition to the more common complications identified, rarer complications which come with significant long-term disability, including stroke, congestive heart failure and cardiac arrest were present in 1 to 5% of patients within our cohort¹⁹⁻²¹. Patients who received critical care had the highest complication rates, compatible with previous observations after critical illness that describe high levels of morbidity in those who survive critical care. The least commonly observed were neurological complications, although these were the most strongly associated with reduced ability to self-care. Suspected bacterial pneumonia and ARDS were the most common respiratory complications. When compared with the published literature on influenza, complications rates in patients with COVID-19 were the same or higher²²⁻²⁴. Interestingly, this appears to be primarily driven by non-infectious complications, as the rates of secondary bacterial infection in patients with COVID-19 appear to be lower compared to the influenza literature²⁵. Notably, COVID-19 patients had up to 19 times the risk of developing ARDS when compared to patients admitted with influenza²⁶.

Most clinical studies of COVID-19 have focussed on the outcome of mortality¹. Mortality is clearly measurable and makes some types of analyses straightforward. However, its use as a sole

outcome in COVID-19 studies, where specific demographic groups are more likely to die (i.e. those with comorbidities or the elderly) may underestimate the detrimental impact of COVID-19 on those who are young or otherwise healthy. Our analysis suggests that the odds of complications are similar for all hospitalised patients over 50 years, not just the elderly. We also observed the differences in number of complications decrease between those who died and those who survived as age increased, suggesting that although young people are less likely to die, they may be proportionally more likely to survive and live with complications. Patients with complications are also likely to have impaired ability to self-care following discharge from hospital. This contradicts current narratives that COVID-19 is only dangerous in people with existing comorbidity and the elderly. Dispelling and contributing to the scientific debate around such narratives has become increasingly important. Many countries including the UK are experiencing further waves of infection, which appears to be driven by infection in younger, healthier people²⁷. Suggestions have been made around using this young, healthy demographic to help support economic output, use in viral challenge studies to test SARS-CoV-2 vaccines and to propagate herd immunity within a population²⁸. Policy makers need to ensure that regarding this group as 'low-risk', based on reduced likelihood of mortality at a population level, may not fully take into account the in-hospital and long-term consequences in younger patients who experienced severe COVID-19.

Our data provide the most comprehensive look to date at the impact of COVID-19 on short-term clinical outcomes in a hospitalised population. Data were collected prospectively and capture the majority of people hospitalised with COVID-19 in the United Kingdom. Recruitment to our study continues, enabling us to capture trends and incidence of complications in near real-time. Other smaller, or single centre studies have typically focussed either exclusively on patients who received critical care, or on one type of complication and lack systematic approaches to data collection⁴. Our study includes patients in both critical care and in ward-level areas. In addition, the multicentre nature of our study across 302 facilities in four countries increases the generalisability of our findings, which is particularly important to provide robust estimates of short-term morbidity for healthcare planners and policy makers. The large sample size of our study allowed us to conduct meaningful subgroup analyses and integrate blood test and microbiology results to increase robustness. This sample size meant we could detect rare events in important patient groups such as those receiving critical care, younger patients, and survivors where complications may have the biggest impact and be with patients for a long period of time after the initial event.

Although it is difficult to disentangle which complications causally contribute toward death and which are confounding associations, we found a significantly higher mortality rate in patients with higher numbers of complications and with more severe COVID-19 in terms of admission to critical care and high 4C Mortality Score. Understanding which patients are likely to suffer specific complications and when may present opportunities for research into early therapeutic interventions to mitigate complications. For example, further characterisation of thromboembolic complications and stroke may assist clinical trials to test anticoagulation strategies in patients with COVID-19²⁹. We found our 4C Mortality Score, along with physiology scores such as qSOFA and NEWS2, predicted the presence of complications thus providing tools to stratify clinical and research populations at the highest risk. Several of the complications we identify in our study may also be mitigated by simple clinical interventions, such as optimising fluid balance to ensure adequate renal perfusion in patients with less severe respiratory disease, or by monitoring and treating patients for cardiac arrhythmias which may lead to further problems such as stroke or cardiac arrest.

There are several limitations to our study, which relate mainly to the design of the study and current unknowns in COVID-19 research. First, our dataset focusses on in-hospital complications during the index admission for COVID-19 and cannot provide longer-term outcome data or data on quality of life. Nevertheless, our results suggest that complications of COVID-19 may affect all survivor groups, rather than just those who are older and have comorbidities. Secondly, the complications that were captured were predefined by a pragmatic outbreak preparedness study protocol, and case report form developed for “Disease X”, and long before the emergence of SARS-CoV-2. The outcomes we chose are both clinically important and associated with complications observed in other infectious viral diseases. Local investigators could enter other complications as free text, but this approach may have missed some important outcomes which were otherwise unexpected (i.e. venous thromboembolism); however, as these emerged we amended the case report form to include these. This suggests our estimates are likely to be conservative, when compared to the incidence of some complications (including PE/ DVT) found in other far smaller studies. Similarly, these smaller studies are more likely to focus on populations with much higher COVID-19 severity, where our study captured all hospital admissions³⁰. Thirdly, our data can only provide estimates of who gets complications in a hospitalised population. We found that even in previously healthy adults with no recorded comorbidity, complications affected more than 4 in 10 hospitalised patients, the effect and burden of which remains undescribed in

the community. For infection related outcomes, we systematically classified microbiological culture results to identify whether infections were caused by pathogenic organisms. However, individuals may have acquired these in the community or in hospital, so our estimates encompass both hospital and community acquired infection. Finally, our data were collected from real-world observed clinical practice and patients did not undergo any additional tests to detect the presence of complications. Therefore, the estimates presented here are likely to be a conservative estimate of the true burden of complications, as it may have missed some physiological, subclinical or longer-term manifestations not detected during clinical care for an acute admission.

Policy makers and healthcare planners should anticipate that large amounts of health and social care resource will be required to support those who survive COVID-19. This includes adequate provision of staffing and equipment; for example, provision of follow-up clinics for those who have sustained in-hospital complications such as acute kidney injury or respiratory tract infection. Beyond the short-term, further work is underway to establish if these in-hospital complications resolve and the long term sequelae experienced by people with COVID-19³¹.

Finally, a large proportion of COVID-19 survivors come from economically active age groups. Morbidity in these groups is likely to have financial and other societal impacts. Governments should plan for long-term health and economic harm caused by morbidity arising from COVID-19. This study has implications for the public messaging around the risk COVID-19 poses for people of all ages; as although mortality may be low in younger people, complication rates are comparable to the rest of the population. Infection prevention and control measures may have additional benefits in preventing long-term disability and modelling studies would be useful to characterise this further.

In summary, we found high rates of complications and poor functional outcomes in survivors of COVID-19, even in young and previously healthy individuals. Common COVID-19 complications identified here are known to be associated with long-term morbidity and an increased risk of death.

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Authorship supplement

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Figures

Figure 1 – Patient inclusion flowchart

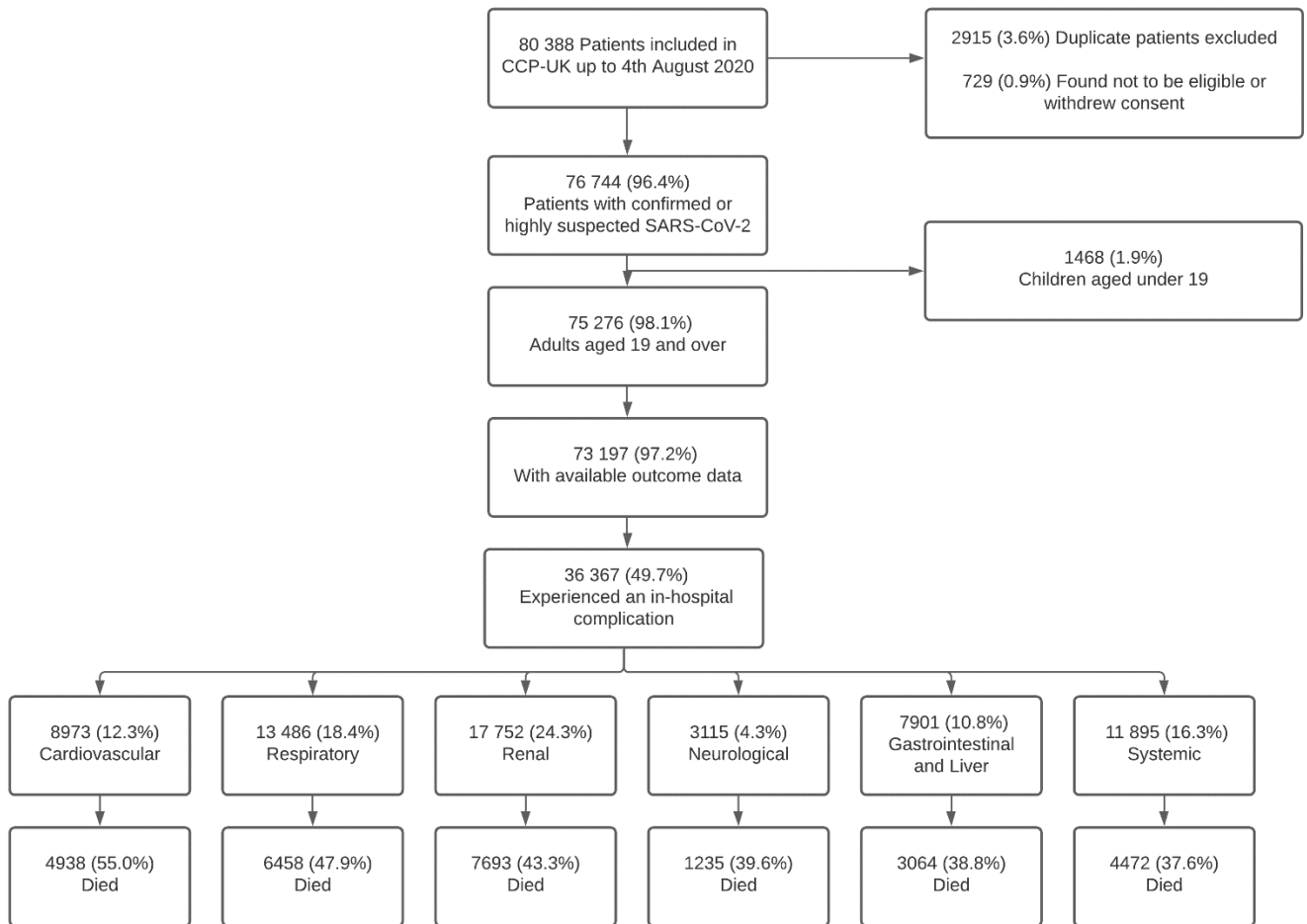


Figure 2 – (A) Clusters of co-occurring complications, measured by the Jaccard index shown in red. (B) In-hospital complications by age, sex, comorbidity and mortality in adults admitted to hospital with severe COVID-19.

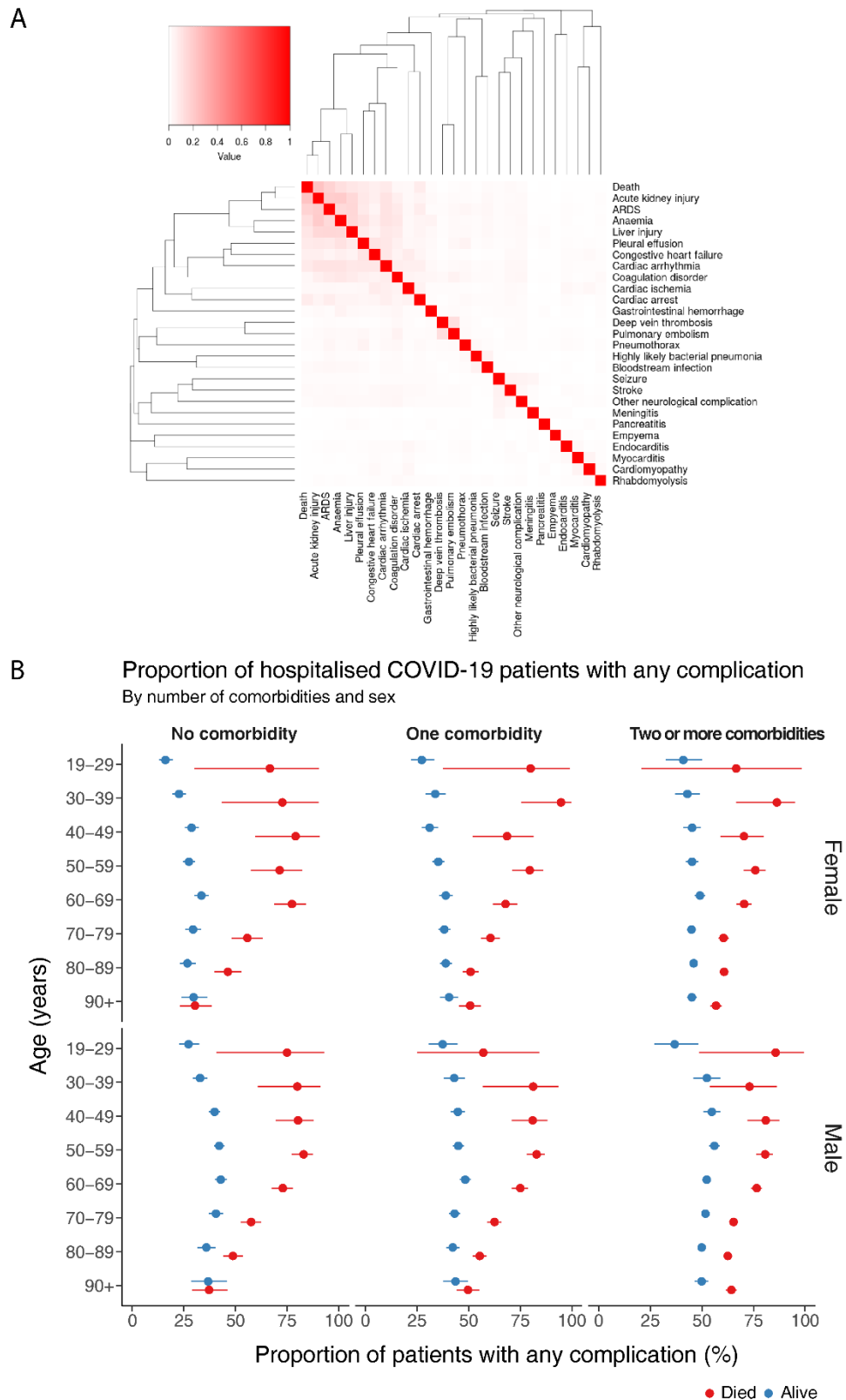


Figure 3 – Associations between in-hospital complications and survival (mortality) in adults admitted to hospital with severe COVID-19. (A) Kaplan-Meier survival curve stratified by number of complications experienced. (B) Hazard Ratios for effect of organ-specific complications on overall survival, adjusted for age, sex, deprivation and centre; supplement pp 11-17 for full models. (C) Effect of organ-specific complications on odds of being admitted to critical care; supplement pp 18-24 for full models.

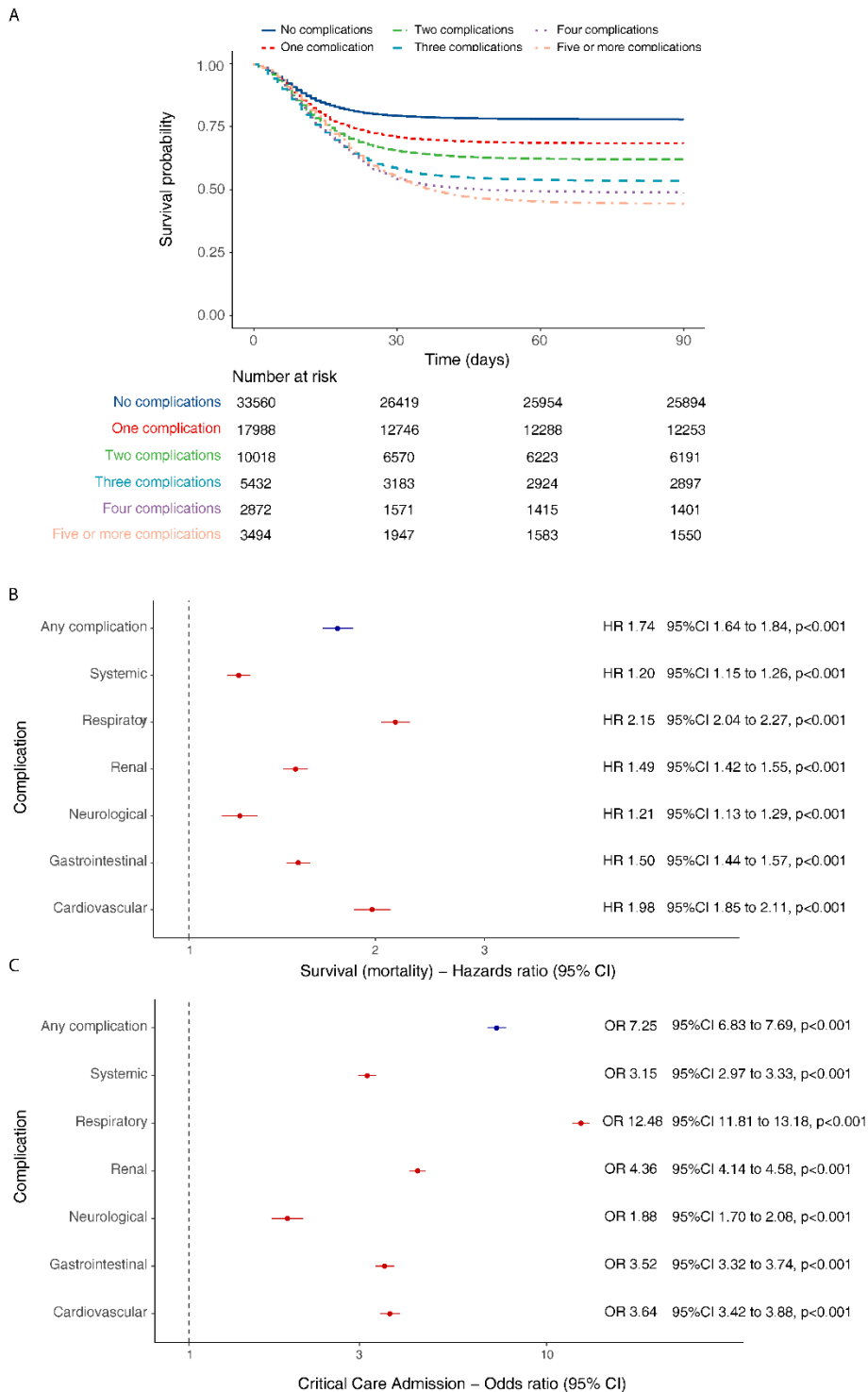
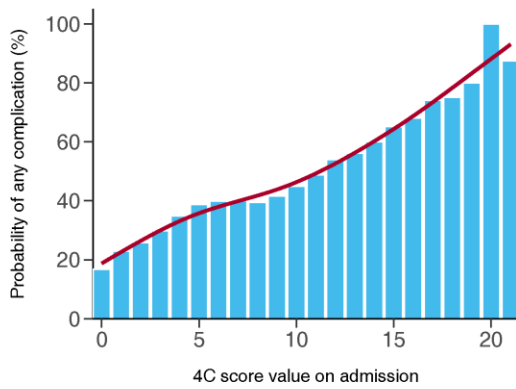
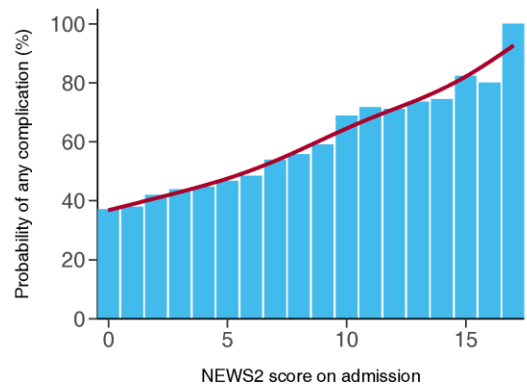


Figure 4 – Probability of complication by admission severity score and symptoms in those who survived. (A) ISARIC 4C mortality score against proportion of patients experiencing any complication. (B) National Early Warning Score 2 against proportion of patients experiencing any complication. (C) Quick Sequential Organ Failure Assessment score against proportion of patients experiencing any complication. (D) Total number of symptoms on admission against proportion of patients experiencing any complication. For continuous outcomes (4C score, NEWS2 and number of symptoms), red line shows smoothed conditional mean line using generalised additive model.

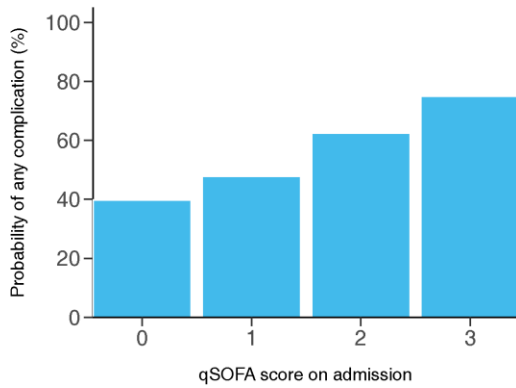
A



B



C



D

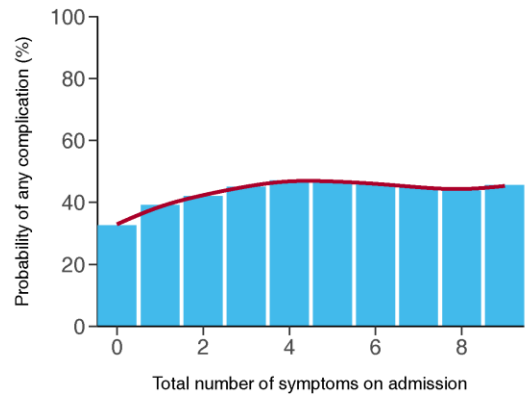
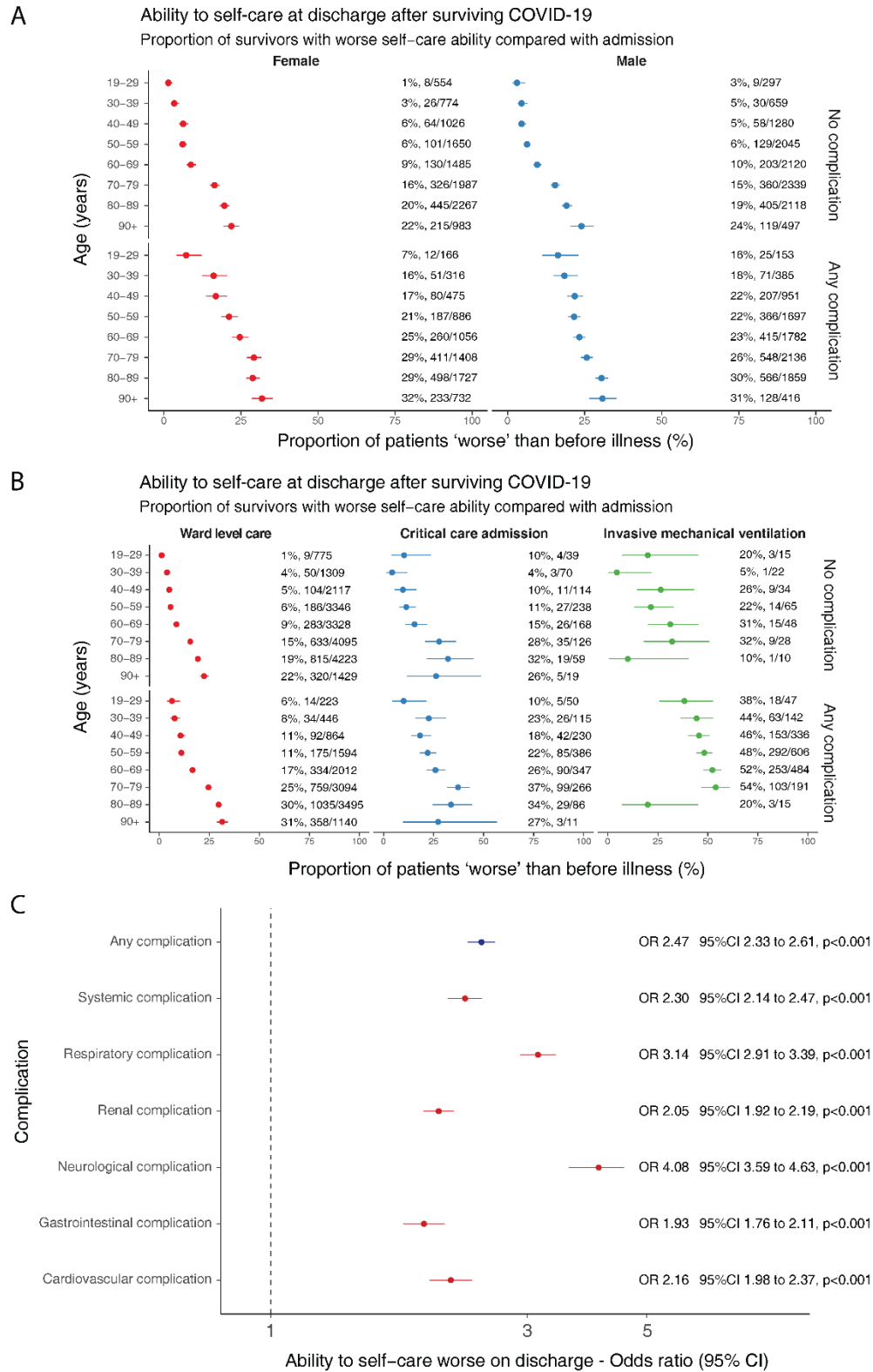


Figure 5 – (A) Ability to self-care at discharge in patients who experienced complications by age group and sex. (B) Ability to self-care at discharge by disease severity. (C) Adjusted odds of worse ability to self-care at discharge by organ-specific complications by complication in adults admitted to hospital with severe COVID-19; Supplementary table 7 – pp25-31 for full models.



Tables

Table 1 – Patient characteristics by organ-specific complications experienced.

		Patients experiencing complications		Organ-specific level complications						
		Total patients	Any complication	Systemic	Renal	GI	Cardiovascular	Neurological	Respiratory*	
Total N (%)		73197	36367 (49.7)	11895 (16.3)	17752 (24.3)	7901 (10.8)	8973 (12.3)	3115 (4.3)	13486 (18.4)	
Age on admission	18-29	1477 (2.0)	405 (27.4)	145 (9.8)	124 (8.4)	139 (9.4)	43 (2.9)	37 (2.5)	142 (9.6)	
	30-39	2707 (3.7)	993 (36.7)	364 (13.4)	342 (12.6)	360 (13.3)	127 (4.7)	87 (3.2)	450 (16.6)	
	40-49	4933 (6.8)	2144 (43.5)	718 (14.6)	859 (17.4)	738 (15.0)	358 (7.3)	160 (3.2)	1152 (23.4)	
	50-59	9009 (12.4)	4380 (48.6)	1483 (16.5)	2056 (22.8)	1459 (16.2)	837 (9.3)	346 (3.8)	2236 (24.8)	
	60-69	11051 (15.2)	5918 (53.6)	1993 (18.0)	3036 (27.5)	1576 (14.3)	1382 (12.5)	496 (4.5)	2748 (24.9)	
	70-79	16481 (22.7)	8518 (51.7)	2710 (16.4)	4304 (26.1)	1642 (10.0)	2213 (13.4)	718 (4.4)	2969 (18.0)	
	80-89	19818 (27.3)	10169 (51.3)	3230 (16.3)	5139 (25.9)	1476 (7.4)	2877 (14.5)	932 (4.7)	2754 (13.9)	
	90+	7220 (9.9)	3637 (50.4)	1157 (16.0)	1785 (24.7)	487 (6.7)	1078 (14.9)	305 (4.2)	946 (13.1)	
	Sex at Birth	Female	31977 (43.8)	14521 (45.4)	4872 (15.2)	6612 (20.7)	2690 (8.4)	3539 (11.1)	1289 (4.0)	4951 (15.5)
	Male	41025 (56.2)	21758 (53.0)	7001 (17.1)	11097 (27.0)	5199 (12.7)	5415 (13.2)	1822 (4.4)	8504 (20.7)	
Deprivation	1	10408 (14.2)	5201 (50.0)	1773 (17.0)	2437 (23.4)	1152 (11.1)	1384 (13.3)	466 (4.5)	1885 (18.1)	
	2	12853 (17.6)	6439 (50.1)	2147 (16.7)	2996 (23.3)	1431 (11.1)	1634 (12.7)	552 (4.3)	2305 (17.9)	
	3	15822 (21.6)	7855 (49.6)	2595 (16.4)	3793 (24.0)	1631 (10.3)	1986 (12.6)	633 (4.0)	3035 (19.2)	
	4	16104 (22.0)	8069 (50.1)	2621 (16.3)	4101 (25.5)	1748 (10.9)	2012 (12.5)	718 (4.5)	3083 (19.1)	
	5	17997 (24.6)	8801 (48.9)	2759 (15.3)	4424 (24.6)	1939 (10.8)	1956 (10.9)	745 (4.1)	3177 (17.7)	
Ethnicity	White	53780 (83.1)	26431 (49.1)	8678 (16.1)	12896 (24.0)	5438 (10.1)	6624 (12.3)	2282 (4.2)	9173 (17.1)	
	South Asian	3318 (5.1)	1630 (49.1)	593 (17.9)	799 (24.1)	441 (13.3)	369 (11.1)	102 (3.1)	777 (23.4)	
	East Asian	484 (0.7)	249 (51.4)	96 (19.8)	113 (23.3)	82 (16.9)	55 (11.4)	15 (3.1)	142 (29.3)	
	Black	2480 (3.8)	1433 (57.8)	508 (20.5)	822 (33.1)	346 (14.0)	306 (12.3)	114 (4.6)	627 (25.3)	
	Other	4646 (7.2)	2435 (52.4)	751 (16.2)	1145 (24.6)	641 (13.8)	491 (10.6)	203 (4.4)	1171 (25.2)	
	Diabetes	No	49765 (75.8)	24481 (49.2)	7878 (15.8)	11265 (22.6)	5694 (11.4)	5948 (12.0)	2173 (4.4)	9194 (18.5)
	Yes	15855 (24.2)	8792 (55.5)	3081 (19.4)	4891 (30.8)	1615 (10.2)	2266 (14.3)	625 (3.9)	3173 (20.0)	
Obesity	No	53415 (87.9)	26397 (49.4)	8476 (15.9)	12656 (23.7)	5784 (10.8)	6331 (11.9)	2304 (4.3)	9498 (17.8)	
	Yes	7329 (12.1)	4230 (57.7)	1583 (21.6)	2208 (30.1)	985 (13.4)	1226 (16.7)	296 (4.0)	2059 (28.1)	
Chronic Cardiac Disease	No	45563 (66.9)	21808 (47.9)	7117 (15.6)	10400 (22.8)	5332 (11.7)	4077 (8.9)	1923 (4.2)	8787 (19.3)	
	Yes	22563 (33.1)	12758 (56.5)	4235 (18.8)	6436 (28.5)	2201 (9.8)	4496 (19.9)	995 (4.4)	4025 (17.8)	
Chronic pulmonary disease	No	55604 (82.0)	27916 (50.2)	9261 (16.7)	13619 (24.5)	6404 (11.5)	6665 (12.0)	2461 (4.4)	10468 (18.8)	
	Yes	12235 (18.0)	6472 (52.9)	2002 (16.4)	3143 (25.7)	1100 (9.0)	1791 (14.6)	444 (3.6)	2289 (18.7)	
Asthma	No	58352 (86.3)	29806 (51.1)	9782 (16.8)	14657 (25.1)	6525 (11.2)	7286 (12.5)	2572 (4.4)	10852 (18.6)	
	Yes	9298 (13.7)	4447 (47.8)	1482 (15.9)	2039 (21.9)	977 (10.5)	1141 (12.3)	320 (3.4)	1849 (19.9)	
Chronic kidney disease	No	55458 (82.0)	26793 (48.3)	8582 (15.5)	11962 (21.6)	6284 (11.3)	6434 (11.6)	2368 (4.3)	10654 (19.2)	
	Yes	12182 (18.0)	7503 (61.6)	2661 (21.8)	4785 (39.3)	1166 (9.6)	2008 (16.5)	525 (4.3)	2070 (17.0)	
Moderate or severe liver disease	No	65646 (98.0)	33005 (50.3)	10769 (16.4)	16111 (24.5)	6879 (10.5)	8162 (12.4)	2764 (4.2)	12314 (18.8)	
	Yes	1340 (2.0)	916 (68.4)	358 (26.7)	413 (30.8)	528 (39.4)	179 (13.4)	96 (7.2)	281 (21.0)	
Mild Liver disease	No	65784 (98.5)	33164 (50.4)	10837 (16.5)	16169 (24.6)	7096 (10.8)	8178 (12.4)	2792 (4.2)	12338 (18.8)	
	Yes	1035 (1.5)	635 (61.4)	240 (23.2)	294 (28.4)	269 (26.0)	132 (12.8)	60 (5.8)	222 (21.4)	
Chronic neurological disorder	No	58511 (86.9)	29546 (50.5)	9725 (16.6)	14440 (24.7)	6700 (11.5)	7357 (12.6)	2048 (3.5)	11352 (19.4)	
	Yes	8802 (13.1)	4559 (51.8)	1467 (16.7)	2167 (24.6)	729 (8.3)	1024 (11.6)	845 (9.6)	1309 (14.9)	
Malignant neoplasm	No	60050 (89.5)	29952 (49.9)	9485 (15.8)	14643 (24.4)	6620 (11.0)	7378 (12.3)	2564 (4.3)	11283 (18.8)	
	Yes	7072 (10.5)	4075 (57.6)	1675 (23.7)	1932 (27.3)	819 (11.6)	994 (14.1)	307 (4.3)	1341 (19.0)	
Chronic hematologic disease	No	64082 (95.6)	32079 (50.1)	10150 (15.8)	15622 (24.4)	6958 (10.9)	7906 (12.3)	2737 (4.3)	12003 (18.7)	
	Yes	2982 (4.4)	1907 (64.0)	1017 (34.1)	942 (31.6)	447 (15.0)	461 (15.5)	122 (4.1)	600 (20.1)	
AIDS/HIV	No	65920 (99.6)	33268 (50.5)	10828 (16.4)	16190 (24.6)	7256 (11.0)	8195 (12.4)	2809 (4.3)	12360 (18.8)	
	Yes	256 (0.4)	149 (58.2)	57 (22.3)	82 (32.0)	42 (16.4)	28 (10.9)	13 (5.1)	57 (22.3)	
Rheumatologic disorder	No	59168 (88.5)	29823 (50.4)	9663 (16.3)	14540 (24.6)	6708 (11.3)	7294 (12.3)	2512 (4.2)	11245 (19.0)	
	Yes	7724 (11.5)	4075 (52.8)	1462 (18.9)	1961 (25.4)	701 (9.1)	1061 (13.7)	353 (4.6)	1358 (17.6)	
Dementia	No	55758 (82.7)	28473 (51.1)	9548 (17.1)	13583 (24.4)	6708 (12.0)	7079 (12.7)	2237 (4.0)	11449 (20.5)	
	Yes	11682 (17.3)	5668 (48.5)	1624 (13.9)	3064 (26.2)	750 (6.4)	1306 (11.2)	645 (5.5)	1239 (10.6)	
Malnutrition	No	61355 (97.2)	30675 (50.0)	9913 (16.2)	14844 (24.2)	6761 (11.0)	7557 (12.3)	2551 (4.2)	11626 (18.9)	
	Yes	1771 (2.8)	1079 (60.9)	459 (25.9)	560 (31.6)	241 (13.6)	247 (13.9)	105 (5.9)	324 (18.3)	
Smoking	Never Smoked	23944 (54.8)	11976 (50.0)	4071 (17.0)	5577 (23.3)	2811 (11.7)	2872 (12.0)	889 (3.7)	4894 (20.4)	
	Yes	3895 (8.9)	1927 (49.5)	677 (17.4)	875 (22.5)	508 (13.0)	459 (11.8)	188 (4.8)	694 (17.8)	
	Former Smoker	15834 (36.3)	8533 (53.9)	2914 (18.4)	4179 (26.4)	1740 (11.0)	2317 (14.6)	630 (4.0)	3304 (20.9)	

Percentage values are row percentages. * = Severe acute respiratory infection was contained within case definition so was not counted as a complication. HIV/AIDS - Human immunodeficiency virus infection and acquired immunodeficiency syndrome, IMD – Index of Multiple Deprivation. GI – Gastrointestinal (including liver).

Table 2 - Outcomes by organ specific complications.

		Patients experiencing complications		Organ-specific level complications					
		Total patients	Any complication	Systemic	Renal	GI	Cardiovascular	Neurological	Respiratory*
Total N (%)		73197	36367 (49.7)	11895 (16.3)	17752 (24.3)	7901 (10.8)	8973 (12.3)	3115 (4.3)	13486 (18.4)
Critical Care Admission	No	62125 (86.1)	28092 (77.3)	8804 (74.0)	12992 (73.2)	5139 (65.1)	6640 (74.0)	2446 (78.5)	7472 (55.4)
	Yes	10034 (13.9)	8267 (22.7)	3090 (26.0)	4755 (26.8)	2760 (34.9)	2333 (26.0)	668 (21.5)	6012 (44.6)
Invasive ventilation	No	65888 (91.5)	30710 (84.5)	9556 (80.4)	14262 (80.4)	5815 (73.7)	7186 (80.1)	2573 (82.6)	8809 (65.4)
	Yes	6122 (8.5)	5619 (15.5)	2330 (19.6)	3471 (19.6)	2077 (26.3)	1784 (19.9)	542 (17.4)	4670 (34.6)
Non-invasive ventilation	No	60035 (84.7)	28202 (78.5)	9228 (78.2)	13361 (76.1)	5685 (72.8)	6862 (77.1)	2566 (83.3)	8332 (62.3)
	Yes	10827 (15.3)	7741 (21.5)	2567 (21.8)	4194 (23.9)	2124 (27.2)	2034 (22.9)	513 (16.7)	5038 (37.7)
Supplemental oxygen	No	17652 (24.7)	5971 (16.5)	2079 (17.6)	2470 (14.0)	1153 (14.7)	1190 (13.3)	737 (23.8)	838 (6.2)
	Yes	53695 (75.3)	30181 (83.5)	9762 (82.4)	15189 (86.0)	6705 (85.3)	7744 (86.7)	2358 (76.2)	12598 (93.8)

Percentage values are column percentages. * = Severe acute respiratory infection was contained within case definition so was not counted as a complication. GI – Gastrointestinal (including liver).

Online supplement

Supplementary table 1A - Specific complications stratified by age and sex in adults admitted to hospital with severe COVID-19.

	Total	19-29	30-39	40-49	50-59	60-69	70-79	80-89	90+	
Female	Total N (%)	31780	868 (2.7)	1340 (4.2)	1936 (6.1)	3458 (10.9)	4202 (13.2)	6654 (20.9)	9141 (28.8)	4181 (13.2)
	Cryptogenic organizing pneumonia	42 (0.1)	0 (0.0)	2 (0.1)	2 (0.1)	4 (0.1)	8 (0.2)	6 (0.1)	10 (0.1)	10 (0.2)
	ARDS	3239 (10.2)	53 (6.1)	144 (10.7)	309 (16.0)	546 (15.8)	700 (16.7)	662 (9.9)	602 (6.6)	223 (5.3)
	Pneumothorax	223 (0.7)	6 (0.7)	10 (0.7)	23 (1.2)	39 (1.1)	57 (1.4)	52 (0.8)	27 (0.3)	9 (0.2)
	Pleural effusion	1931 (6.1)	16 (1.8)	47 (3.5)	82 (4.2)	141 (4.1)	266 (6.3)	421 (6.3)	639 (7.0)	319 (7.6)
	Highly likely Bacterial Pneumonia	99 (0.3)	2 (0.2)	4 (0.3)	14 (0.7)	25 (0.7)	21 (0.5)	21 (0.3)	10 (0.1)	2 (0.0)
	Meningitis / Encephalitis	61 (0.2)	2 (0.2)	4 (0.3)	7 (0.4)	7 (0.2)	19 (0.5)	8 (0.1)	11 (0.1)	3 (0.1)
	Seizure	331 (1.0)	6 (0.7)	17 (1.3)	22 (1.1)	46 (1.3)	46 (1.1)	79 (1.2)	87 (1.0)	28 (0.7)
	Stroke / Cerebrovascular accident	479 (1.5)	2 (0.2)	5 (0.4)	13 (0.7)	30 (0.9)	67 (1.6)	105 (1.6)	175 (1.9)	82 (2.0)
	Other neurological complication	528 (1.7)	7 (0.8)	8 (0.6)	22 (1.1)	41 (1.2)	69 (1.6)	103 (1.5)	195 (2.1)	83 (2.0)
	Congestive heart failure	1130 (3.6)	0 (0.0)	5 (0.4)	16 (0.8)	33 (1.0)	93 (2.2)	243 (3.7)	484 (5.3)	256 (6.1)
	Endocarditis / Myocarditis	83 (0.3)	1 (0.1)	5 (0.4)	6 (0.3)	11 (0.3)	19 (0.5)	23 (0.3)	14 (0.2)	4 (0.1)
	Pericarditis	69 (0.2)	2 (0.2)	4 (0.3)	5 (0.3)	13 (0.4)	16 (0.4)	13 (0.2)	10 (0.1)	6 (0.1)
	Cardiomyopathy	77 (0.2)	0 (0.0)	1 (0.1)	6 (0.3)	9 (0.3)	8 (0.2)	16 (0.2)	28 (0.3)	9 (0.2)
	Cardiac arrhythmia	1887 (5.9)	13 (1.5)	29 (2.2)	82 (4.2)	139 (4.0)	224 (5.3)	426 (6.4)	674 (7.4)	300 (7.2)
	Cardiac ischemia	380 (1.2)	0 (0.0)	3 (0.2)	6 (0.3)	29 (0.8)	42 (1.0)	90 (1.4)	137 (1.5)	73 (1.7)
	Cardiac arrest	651 (2.0)	4 (0.5)	13 (1.0)	24 (1.2)	65 (1.9)	93 (2.2)	161 (2.4)	200 (2.2)	91 (2.2)
	Bloodstream infection	404 (1.3)	6 (0.7)	22 (1.6)	34 (1.8)	48 (1.4)	71 (1.7)	76 (1.1)	105 (1.1)	42 (1.0)
	Coagulation disorder / DIC	711 (2.2)	14 (1.6)	22 (1.6)	45 (2.3)	97 (2.8)	134 (3.2)	144 (2.2)	187 (2.0)	68 (1.6)
	Anaemia	4103 (12.9)	80 (9.2)	159 (11.9)	247 (12.8)	428 (12.4)	625 (14.9)	849 (12.8)	1185 (13.0)	530 (12.7)
	Rhabdomyolysis / Myositis	97 (0.3)	3 (0.3)	1 (0.1)	1 (0.1)	9 (0.3)	11 (0.3)	14 (0.2)	35 (0.4)	23 (0.6)
	Acute Kidney Injury	6587 (20.7)	51 (5.9)	123 (9.2)	248 (12.8)	637 (18.4)	928 (22.1)	1530 (23.0)	2129 (23.3)	941 (22.5)
	Gastrointestinal haemorrhage	324 (1.0)	5 (0.6)	8 (0.6)	8 (0.4)	25 (0.7)	47 (1.1)	57 (0.9)	120 (1.3)	54 (1.3)
	Pancreatitis	107 (0.3)	5 (0.6)	8 (0.6)	9 (0.5)	17 (0.5)	24 (0.6)	16 (0.2)	22 (0.2)	6 (0.1)
	Deep Vein Thrombosis	160 (0.5)	2 (0.2)	9 (0.7)	9 (0.5)	29 (0.8)	31 (0.7)	29 (0.4)	40 (0.4)	11 (0.3)
	Pulmonary Embolism	377 (1.2)	3 (0.3)	15 (1.1)	27 (1.4)	64 (1.9)	82 (2.0)	77 (1.2)	88 (1.0)	21 (0.5)
	Liver Injury	2362 (7.4)	48 (5.5)	113 (8.4)	191 (9.9)	407 (11.8)	430 (10.2)	475 (7.1)	500 (5.5)	198 (4.7)
Male	Total N (%)	40725	603 (1.5)	1359 (3.3)	2983 (7.3)	5530 (13.6)	6823 (16.8)	9790 (24.0)	10618 (26.1)	3019 (7.4)
	Cryptogenic organizing pneumonia	50 (0.1)	0 (0.0)	2 (0.1)	4 (0.1)	9 (0.2)	12 (0.2)	10 (0.1)	12 (0.1)	1 (0.0)
	ARDS	6367 (15.6)	61 (10.1)	242 (17.8)	686 (23.0)	1362 (24.6)	1529 (22.4)	1406 (14.4)	886 (8.3)	195 (6.5)
	Pneumothorax	454 (1.1)	6 (1.0)	19 (1.4)	45 (1.5)	104 (1.9)	121 (1.8)	87 (0.9)	55 (0.5)	17 (0.6)
	Pleural effusion	2562 (6.3)	21 (3.5)	50 (3.7)	145 (4.9)	315 (5.7)	448 (6.6)	627 (6.4)	722 (6.8)	234 (7.8)
	Highly likely Bacterial Pneumonia	260 (0.6)	1 (0.2)	10 (0.7)	38 (1.3)	78 (1.4)	60 (0.9)	54 (0.6)	17 (0.2)	2 (0.1)
	Meningitis / Encephalitis	94 (0.2)	5 (0.8)	4 (0.3)	14 (0.5)	20 (0.4)	23 (0.3)	12 (0.1)	16 (0.2)	0 (0.0)
	Seizure	492 (1.2)	13 (2.2)	31 (2.3)	44 (1.5)	88 (1.6)	87 (1.3)	104 (1.1)	105 (1.0)	20 (0.7)
	Stroke / Cerebrovascular accident	723 (1.8)	1 (0.2)	10 (0.7)	35 (1.2)	74 (1.3)	146 (2.1)	204 (2.1)	209 (2.0)	44 (1.5)
	Other neurological complication	682 (1.7)	6 (1.0)	17 (1.3)	31 (1.0)	89 (1.6)	94 (1.4)	172 (1.8)	208 (2.0)	65 (2.2)

	Total	19-29	30-39	40-49	50-59	60-69	70-79	80-89	90+
Congestive heart failure	1386 (3.4)	0 (0.0)	11 (0.8)	27 (0.9)	83 (1.5)	184 (2.7)	363 (3.7)	539 (5.1)	179 (5.9)
Endocarditis / Myocarditis / Pericarditis	179 (0.4)	1 (0.2)	10 (0.7)	19 (0.6)	29 (0.5)	44 (0.6)	39 (0.4)	36 (0.3)	1 (0.0)
Myocarditis / Pericarditis	121 (0.3)	1 (0.2)	3 (0.2)	20 (0.7)	19 (0.3)	22 (0.3)	28 (0.3)	22 (0.2)	6 (0.2)
Cardiomyopathy	93 (0.2)	0 (0.0)	2 (0.1)	9 (0.3)	13 (0.2)	20 (0.3)	24 (0.2)	21 (0.2)	4 (0.1)
Cardiac arrhythmia	2905 (7.1)	19 (3.2)	45 (3.3)	137 (4.6)	360 (6.5)	594 (8.7)	786 (8.0)	755 (7.1)	209 (6.9)
Cardiac ischemia	612 (1.5)	0 (0.0)	10 (0.7)	19 (0.6)	54 (1.0)	106 (1.6)	175 (1.8)	186 (1.8)	62 (2.1)
Cardiac arrest	1240 (3.0)	4 (0.7)	19 (1.4)	66 (2.2)	171 (3.1)	236 (3.5)	327 (3.3)	314 (3.0)	103 (3.4)
Bloodstream infection	710 (1.7)	9 (1.5)	29 (2.1)	65 (2.2)	99 (1.8)	142 (2.1)	154 (1.6)	166 (1.6)	46 (1.5)
Coagulation disorder / DIC	1316 (3.2)	12 (2.0)	53 (3.9)	123 (4.1)	250 (4.5)	268 (3.9)	292 (3.0)	251 (2.4)	67 (2.2)
Anaemia	5723 (14.1)	38 (6.3)	138 (10.2)	324 (10.9)	785 (14.2)	1035 (15.2)	1423 (14.5)	1530 (14.4)	450 (14.9)
Rhabdomyolysis / Myositis	163 (0.4)	5 (0.8)	5 (0.4)	12 (0.4)	24 (0.4)	18 (0.3)	42 (0.4)	41 (0.4)	16 (0.5)
Acute Kidney Injury	11016 (27.0)	73 (12.1)	219 (16.1)	608 (20.4)	1417 (25.6)	2102 (30.8)	2764 (28.2)	2993 (28.2)	840 (27.8)
Gastrointestinal haemorrhage	521 (1.3)	5 (0.8)	9 (0.7)	32 (1.1)	60 (1.1)	90 (1.3)	119 (1.2)	159 (1.5)	47 (1.6)
Pancreatitis	139 (0.3)	6 (1.0)	18 (1.3)	18 (0.6)	36 (0.7)	21 (0.3)	23 (0.2)	14 (0.1)	3 (0.1)
Deep Vein Thrombosis	250 (0.6)	1 (0.2)	6 (0.4)	21 (0.7)	56 (1.0)	52 (0.8)	57 (0.6)	44 (0.4)	13 (0.4)
Pulmonary Embolism	610 (1.5)	10 (1.7)	13 (1.0)	74 (2.5)	136 (2.5)	134 (2.0)	135 (1.4)	95 (0.9)	13 (0.4)
Liver Injury	4721 (11.6)	80 (13.3)	219 (16.1)	514 (17.2)	985 (17.8)	1027 (15.1)	997 (10.2)	712 (6.7)	187 (6.2)

Percentage values are row percentages. ARDS – Acute Respiratory Distress Syndrome, DIC – Disseminated Intravascular Coagulation.

Supplementary table 1B – Comparison between suspected and highly likely bacterial pneumonia by age and sex in adults admitted to hospital with severe COVID-19.

			Age group (years)							
Total N			19-29	30-39	40-49	50-59	60-69	70-79	80-89	90+
Female	Total N (%)	31780	868 (2.7)	1340 (4.2)	1936 (6.1)	3458 (10.9)	4202 (13.2)	6654 (20.9)	9141 (28.8)	4181 (13.2)
	Suspected Bacterial Pneumonia	3509 (100)	42 (1.2)	100 (2.8)	185 (5.3)	396 (11.3)	536 (15.3)	769 (21.9)	1023 (29.2)	458 (13.1)
	Highly likely Bacterial Pneumonia	99 (100)	2 (2.0)	4 (4.0)	14 (14.1)	25 (25.3)	21 (21.2)	21 (21.2)	10 (10.1)	2 (2.0)
Male	Total N (%)	40725	603 (1.5)	1359 (3.3)	2983 (7.3)	5530 (13.6)	6823 (16.8)	9790 (24.0)	10618 (26.1)	3019 (7.4)
	Suspected Bacterial Pneumonia	5269 (100)	50 (0.9)	145 (2.8)	396 (7.5)	751 (14.3)	921 (17.5)	1273 (24.2)	1345 (25.5)	388 (7.4)
	Highly likely Bacterial Pneumonia	260 (100)	1 (0.4)	10 (3.8)	38 (14.6)	78 (30.0)	60 (23.1)	54 (20.8)	17 (6.5)	2 (0.8)

Percentage values are row percentages

Supplementary table 1C- Comparison between suspected and highly likely bacterial pneumonia by number of existing comorbidities in adults admitted to hospital with severe COVID-19.

Number of existing comorbidities on admission			Age group (years)								
			19-29	30-39	40-49	50-59	60-69	70-79	80-89	90+	
0	Total N (%)	13421	839 (6.3)	1384 (10.3)	2077 (15.5)	2817 (21.0)	2255 (16.8)	1847 (13.8)	1623 (12.1)	579 (4.3)	
	Suspected Bacterial Pneumonia	1402 (100)	41 (2.9)	108 (7.7)	225 (16.0)	334 (23.8)	303 (21.6)	201 (14.3)	142 (10.1)	48 (3.4)	
	Highly likely Bacterial Pneumonia	111 (100)	1 (0.9)	6 (5.4)	23 (20.7)	39 (35.1)	21 (18.9)	19 (17.1)	2 (1.8)	0 (0.0)	
1	Total N (%)	17630	434 (2.5)	780 (4.4)	1550 (8.8)	2850 (16.2)	3029 (17.2)	3785 (21.5)	3767 (21.4)	1435 (8.1)	
	Suspected Bacterial Pneumonia	2105 (100)	33 (1.6)	76 (3.6)	199 (9.5)	369 (17.5)	390 (18.5)	458 (21.8)	425 (20.2)	155 (7.4)	
	Highly likely Bacterial Pneumonia	107 (100)	1 (0.9)	5 (4.7)	14 (13.1)	40 (37.4)	23 (21.5)	19 (17.8)	4 (3.7)	1 (0.9)	
2+	Total N (%)	41645	204 (0.5)	543 (1.3)	1306 (3.1)	3342 (8.0)	5767 (13.8)	10849 (26.1)	14428 (34.6)	5206 (12.5)	
	Suspected Bacterial Pneumonia	5287 (100)	18 (0.3)	62 (1.2)	160 (3.0)	445 (8.4)	766 (14.5)	1389 (26.3)	1804 (34.1)	643 (12.2)	
	Highly likely Bacterial Pneumonia	141 (100)	1 (0.7)	3 (2.1)	15 (10.6)	24 (17.0)	37 (26.2)	37 (26.2)	21 (14.9)	3 (2.1)	

Percentage values are row percentages

Supplementary table 2 - Organ specific complications stratified by age and presence of comorbidity in adults admitted to hospital with severe COVID-19 in adults admitted to hospital with severe COVID-19.

Number of existing comorbidities on admission			Age group (years)							
			19-29	30-39	40-49	50-59	60-69	70-79	80-89	90+
0	Total N (%)	13421	839 (6.3)	1384 (10.3)	2077 (15.5)	2817 (21.0)	2255 (16.8)	1847 (13.8)	1623 (12.1)	579 (4.3)
	Systemic	1521 (11.3)	59 (7.0)	141 (10.2)	232 (11.2)	347 (12.3)	319 (14.1)	217 (11.7)	149 (9.2)	57 (9.8)
	Renal	2066 (15.4)	43 (5.1)	111 (8.0)	258 (12.4)	475 (16.9)	479 (21.2)	352 (19.1)	260 (16.0)	88 (15.2)
	Gastrointestinal	1633 (12.2)	64 (7.6)	157 (11.3)	297 (14.3)	450 (16.0)	318 (14.1)	208 (11.3)	109 (6.7)	30 (5.2)
	Cardiovascular	989 (7.4)	17 (2.0)	39 (2.8)	122 (5.9)	202 (7.2)	212 (9.4)	192 (10.4)	152 (9.4)	53 (9.2)
	Neurological	375 (2.8)	11 (1.3)	31 (2.2)	50 (2.4)	69 (2.4)	74 (3.3)	58 (3.1)	70 (4.3)	12 (2.1)
	Respiratory	2475 (18.4)	58 (6.9)	178 (12.9)	445 (21.4)	649 (23.0)	577 (25.6)	364 (19.7)	158 (9.7)	46 (7.9)
	Any complication	5129 (38.2)	178 (21.2)	405 (29.3)	790 (38.0)	1146 (40.7)	1024 (45.4)	781 (42.3)	614 (37.8)	191 (33.0)
	1	Total N (%)	17630	434 (2.5)	780 (4.4)	1550 (8.8)	2850 (16.2)	3029 (17.2)	3785 (21.5)	3767 (21.4)
Systemic		2495 (14.2)	49 (11.3)	113 (14.5)	218 (14.1)	439 (15.4)	516 (17.0)	508 (13.4)	468 (12.4)	184 (12.8)
Renal		3746 (21.2)	42 (9.7)	105 (13.5)	261 (16.8)	603 (21.2)	795 (26.2)	867 (22.9)	795 (21.1)	278 (19.4)
Gastrointestinal		2021 (11.5)	50 (11.5)	112 (14.4)	235 (15.2)	450 (15.8)	454 (15.0)	380 (10.0)	244 (6.5)	96 (6.7)
Cardiovascular		1801 (10.2)	14 (3.2)	52 (6.7)	103 (6.6)	255 (8.9)	353 (11.7)	427 (11.3)	417 (11.1)	180 (12.5)
Neurological		693 (3.9)	17 (3.9)	27 (3.5)	52 (3.4)	105 (3.7)	141 (4.7)	145 (3.8)	155 (4.1)	51 (3.6)
Respiratory		3416 (19.4)	55 (12.7)	155 (19.9)	331 (21.4)	716 (25.1)	797 (26.3)	707 (18.7)	488 (13.0)	167 (11.6)
Any complication		8197 (46.5)	142 (32.7)	316 (40.5)	653 (42.1)	1334 (46.8)	1554 (51.3)	1814 (47.9)	1730 (45.9)	654 (45.6)
2+		Total N (%)	41645	204 (0.5)	543 (1.3)	1306 (3.1)	3342 (8.0)	5767 (13.8)	10849 (26.1)	14428 (34.6)
	Systemic	7784 (18.7)	37 (18.1)	110 (20.3)	268 (20.5)	697 (20.9)	1158 (20.1)	1985 (18.3)	2613 (18.1)	916 (17.6)
	Renal	11833 (28.4)	39 (19.1)	126 (23.2)	340 (26.0)	978 (29.3)	1762 (30.6)	3085 (28.4)	4084 (28.3)	1419 (27.3)
	Gastrointestinal	4223 (10.1)	25 (12.3)	91 (16.8)	206 (15.8)	559 (16.7)	804 (13.9)	1054 (9.7)	1123 (7.8)	361 (6.9)
	Cardiovascular	6125 (14.7)	12 (5.9)	36 (6.6)	133 (10.2)	380 (11.4)	817 (14.2)	1594 (14.7)	2308 (16.0)	845 (16.2)
	Neurological	2013 (4.8)	9 (4.4)	29 (5.3)	58 (4.4)	172 (5.1)	281 (4.9)	515 (4.7)	707 (4.9)	242 (4.6)
	Respiratory	7506 (18.0)	29 (14.2)	117 (21.5)	376 (28.8)	871 (26.1)	1374 (23.8)	1898 (17.5)	2108 (14.6)	733 (14.1)
	Any complication	22838 (54.8)	85 (41.7)	272 (50.1)	701 (53.7)	1900 (56.9)	3340 (57.9)	5923 (54.6)	7825 (54.2)	2792 (53.6)

Percentage values are column percentages.

Supplementary table 3 - Specific complications stratified by age and presence of comorbidity in adults admitted to hospital with severe COVID-19.

			Age group (years)							
Number of existing comorbidities on admission		Total	19-29	30-39	40-49	50-59	60-69	70-79	80-89	90+
			0	Total N (%)	13421	839 (6.3)	1384 (10.3)	2077 (15.5)	2817 (21.0)	2255 (16.8)
	Empyema	12 (0.1)	0 (0.0)	1 (0.1)	2 (0.1)	2 (0.1)	4 (0.2)	2 (0.1)	1 (0.1)	0 (0.0)
	ARDS	2105 (15.7)	43 (5.1)	150 (10.8)	390 (18.8)	574 (20.4)	511 (22.7)	306 (16.6)	110 (6.8)	21 (3.6)
	Pneumothorax	158 (1.2)	9 (1.1)	12 (0.9)	26 (1.3)	42 (1.5)	44 (2.0)	21 (1.1)	2 (0.1)	2 (0.3)
	Pleural effusion	536 (4.0)	19 (2.3)	38 (2.7)	87 (4.2)	113 (4.0)	113 (5.0)	89 (4.8)	53 (3.3)	24 (4.1)
	Highly likely Bacterial Pneumonia	111 (0.8)	1 (0.1)	6 (0.4)	23 (1.1)	39 (1.4)	21 (0.9)	19 (1.0)	2 (0.1)	0 (0.0)
	Meningitis / Encephalitis	40 (0.3)	5 (0.6)	5 (0.4)	6 (0.3)	6 (0.2)	9 (0.4)	4 (0.2)	4 (0.2)	1 (0.2)
	Seizure	101 (0.8)	6 (0.7)	16 (1.2)	17 (0.8)	23 (0.8)	14 (0.6)	11 (0.6)	13 (0.8)	1 (0.2)
	Stroke / Cerebrovascular accident	179 (1.3)	0 (0.0)	5 (0.4)	16 (0.8)	25 (0.9)	41 (1.8)	41 (2.2)	45 (2.8)	6 (1.0)
	Other neurological complication	94 (0.7)	1 (0.1)	6 (0.4)	17 (0.8)	23 (0.8)	22 (1.0)	8 (0.4)	12 (0.7)	5 (0.9)
	Congestive heart failure	108 (0.8)	0 (0.0)	5 (0.4)	7 (0.3)	14 (0.5)	16 (0.7)	23 (1.2)	26 (1.6)	17 (2.9)
	Endocarditis / Myocarditis	50 (0.4)	0 (0.0)	5 (0.4)	10 (0.5)	8 (0.3)	17 (0.8)	6 (0.3)	3 (0.2)	1 (0.2)
	Pericarditis	40 (0.3)	1 (0.1)	3 (0.2)	11 (0.5)	13 (0.5)	7 (0.3)	2 (0.1)	3 (0.2)	0 (0.0)
	Myocarditis / Pericarditis	13 (0.1)	0 (0.0)	1 (0.1)	3 (0.1)	2 (0.1)	5 (0.2)	1 (0.1)	1 (0.1)	0 (0.0)
	Cardiomyopathy	625 (4.7)	12 (1.4)	24 (1.7)	79 (3.8)	130 (4.6)	152 (6.7)	123 (6.7)	77 (4.7)	28 (4.8)
	Cardiac arrhythmia	80 (0.6)	0 (0.0)	7 (0.5)	7 (0.3)	11 (0.4)	14 (0.6)	16 (0.9)	20 (1.2)	5 (0.9)
	Cardiac ischaemia	258 (1.9)	6 (0.7)	6 (0.4)	32 (1.5)	50 (1.8)	48 (2.1)	63 (3.4)	43 (2.6)	10 (1.7)
	Cardiac arrest	193 (1.4)	3 (0.4)	20 (1.4)	36 (1.7)	38 (1.3)	43 (1.9)	26 (1.4)	20 (1.2)	7 (1.2)
	Bloodstream Infection	343 (2.6)	9 (1.1)	34 (2.5)	62 (3.0)	80 (2.8)	74 (3.3)	53 (2.9)	23 (1.4)	8 (1.4)
	Coagulation disorder / DIC	1192 (8.9)	51 (6.1)	108 (7.8)	174 (8.4)	278 (9.9)	251 (11.1)	176 (9.5)	109 (6.7)	45 (7.8)
	Anaemia	42 (0.3)	2 (0.2)	2 (0.1)	8 (0.4)	9 (0.3)	4 (0.2)	7 (0.4)	6 (0.4)	4 (0.7)
	Rhabdomyolysis / Myositis	2066 (15.4)	43 (5.1)	111 (8.0)	258 (12.4)	475 (16.9)	479 (21.2)	352 (19.1)	260 (16.0)	88 (15.2)
	Acute Kidney Injury	78 (0.6)	6 (0.7)	5 (0.4)	7 (0.3)	16 (0.6)	19 (0.8)	7 (0.4)	14 (0.9)	4 (0.7)
	Gastrointestinal haemorrhage	42 (0.3)	5 (0.6)	9 (0.7)	4 (0.2)	11 (0.4)	5 (0.2)	5 (0.3)	1 (0.1)	2 (0.3)
	Pancreatitis	81 (0.6)	2 (0.2)	6 (0.4)	11 (0.5)	26 (0.9)	20 (0.9)	9 (0.5)	5 (0.3)	2 (0.3)
	Deep Vein Thrombosis	240 (1.8)	4 (0.5)	18 (1.3)	44 (2.1)	74 (2.6)	51 (2.3)	31 (1.7)	16 (1.0)	2 (0.3)
	Pulmonary Embolism	1551 (11.6)	58 (6.9)	146 (10.5)	291 (14.0)	435 (15.4)	302 (13.4)	200 (10.8)	95 (5.9)	24 (4.1)
1	Total N (%)	17630	434 (2.5)	780 (4.4)	1550 (8.8)	2850 (16.2)	3029 (17.2)	3785 (21.5)	3767 (21.4)	1435 (8.1)
	Empyema	23 (0.1)	0 (0.0)	3 (0.4)	2 (0.1)	3 (0.1)	6 (0.2)	3 (0.1)	3 (0.1)	3 (0.2)
	ARDS	2653 (15.0)	49 (11.3)	132 (16.9)	293 (18.9)	627 (22.0)	677 (22.4)	526 (13.9)	275 (7.3)	74 (5.2)
	Pneumothorax	208 (1.2)	2 (0.5)	8 (1.0)	22 (1.4)	55 (1.9)	59 (1.9)	41 (1.1)	16 (0.4)	5 (0.3)
	Pleural effusion	959 (5.4)	10 (2.3)	34 (4.4)	56 (3.6)	129 (4.5)	187 (6.2)	217 (5.7)	226 (6.0)	100 (7.0)
	Highly likely Bacterial Pneumonia	107 (0.6)	1 (0.2)	5 (0.6)	14 (0.9)	40 (1.4)	23 (0.8)	19 (0.5)	4 (0.1)	1 (0.1)

Number of existing comorbidities on admission		Total	Age group (years)							
			19-29	30-39	40-49	50-59	60-69	70-79	80-89	90+
Meningitis / Encephalitis	33 (0.2)	1 (0.2)	3 (0.4)	3 (0.2)	6 (0.2)	10 (0.3)	7 (0.2)	3 (0.1)	0 (0.0)	
Seizure	178 (1.0)	7 (1.6)	16 (2.1)	26 (1.7)	34 (1.2)	36 (1.2)	20 (0.5)	29 (0.8)	10 (0.7)	
Stroke / Cerebrovascular accident	293 (1.7)	2 (0.5)	3 (0.4)	16 (1.0)	33 (1.2)	55 (1.8)	81 (2.1)	76 (2.0)	27 (1.9)	
Other neurological complication	262 (1.5)	9 (2.1)	11 (1.4)	17 (1.1)	44 (1.5)	51 (1.7)	53 (1.4)	61 (1.6)	16 (1.1)	
Congestive heart failure	316 (1.8)	0 (0.0)	5 (0.6)	9 (0.6)	24 (0.8)	47 (1.6)	78 (2.1)	90 (2.4)	63 (4.4)	
Endocarditis / Myocarditis	70 (0.4)	0 (0.0)	8 (1.0)	6 (0.4)	14 (0.5)	19 (0.6)	13 (0.3)	8 (0.2)	2 (0.1)	
Pericarditis	53 (0.3)	1 (0.2)	2 (0.3)	8 (0.5)	8 (0.3)	12 (0.4)	13 (0.3)	7 (0.2)	2 (0.1)	
Myocarditis / Pericarditis	34 (0.2)	0 (0.0)	1 (0.1)	5 (0.3)	8 (0.3)	5 (0.2)	8 (0.2)	6 (0.2)	1 (0.1)	
Cardiomyopathy	1082 (6.1)	12 (2.8)	28 (3.6)	66 (4.3)	159 (5.6)	229 (7.6)	268 (7.1)	231 (6.1)	89 (6.2)	
Cardiac arrhythmia	176 (1.0)	0 (0.0)	5 (0.6)	7 (0.5)	23 (0.8)	37 (1.2)	45 (1.2)	43 (1.1)	16 (1.1)	
Cardiac ischaemia	461 (2.6)	1 (0.2)	16 (2.1)	27 (1.7)	87 (3.1)	96 (3.2)	98 (2.6)	95 (2.5)	41 (2.9)	
Cardiac arrest	296 (1.7)	9 (2.1)	19 (2.4)	34 (2.2)	58 (2.0)	61 (2.0)	53 (1.4)	48 (1.3)	14 (1.0)	
Bloodstream Infection	489 (2.8)	12 (2.8)	22 (2.8)	51 (3.3)	106 (3.7)	126 (4.2)	96 (2.5)	56 (1.5)	20 (1.4)	
Coagulation disorder / DIC	2012 (11.4)	34 (7.8)	92 (11.8)	173 (11.2)	351 (12.3)	419 (13.8)	407 (10.8)	380 (10.1)	156 (10.9)	
Anaemia	54 (0.3)	4 (0.9)	1 (0.1)	4 (0.3)	9 (0.3)	7 (0.2)	14 (0.4)	13 (0.3)	2 (0.1)	
Rhabdomyolysis / Myositis	3746 (21.2)	42 (9.7)	105 (13.5)	261 (16.8)	603 (21.2)	795 (26.2)	867 (22.9)	795 (21.1)	278 (19.4)	
Acute Kidney Injury	187 (1.1)	2 (0.5)	4 (0.5)	21 (1.4)	29 (1.0)	38 (1.3)	29 (0.8)	41 (1.1)	23 (1.6)	
Gastrointestinal haemorrhage	67 (0.4)	3 (0.7)	7 (0.9)	10 (0.6)	17 (0.6)	14 (0.5)	8 (0.2)	7 (0.2)	1 (0.1)	
Pancreatitis	102 (0.6)	0 (0.0)	2 (0.3)	14 (0.9)	19 (0.7)	26 (0.9)	26 (0.7)	13 (0.3)	2 (0.1)	
Deep Vein Thrombosis	261 (1.5)	6 (1.4)	6 (0.8)	31 (2.0)	50 (1.8)	64 (2.1)	51 (1.3)	47 (1.2)	6 (0.4)	
Pulmonary Embolism	1859 (10.5)	48 (11.1)	105 (13.5)	220 (14.2)	430 (15.1)	425 (14.0)	351 (9.3)	205 (5.4)	75 (5.2)	
Liver Injury	2+ Total N (%)	41645	204 (0.5)	543 (1.3)	1306 (3.1)	3342 (8.0)	5767 (13.8)	10849 (26.1)	14428 (34.6)	5206 (12.5)
Empyema	57 (0.1)	0 (0.0)	0 (0.0)	2 (0.2)	8 (0.2)	10 (0.2)	11 (0.1)	18 (0.1)	8 (0.2)	
ARDS	4870 (11.7)	23 (11.3)	106 (19.5)	314 (24.0)	709 (21.2)	1043 (18.1)	1242 (11.4)	1108 (7.7)	325 (6.2)	
Pneumothorax	312 (0.7)	1 (0.5)	9 (1.7)	21 (1.6)	46 (1.4)	75 (1.3)	77 (0.7)	64 (0.4)	19 (0.4)	
Pleural effusion	3006 (7.2)	8 (3.9)	25 (4.6)	85 (6.5)	214 (6.4)	416 (7.2)	743 (6.8)	1085 (7.5)	430 (8.3)	
Highly likely Bacterial Pneumonia	141 (0.3)	1 (0.5)	3 (0.6)	15 (1.1)	24 (0.7)	37 (0.6)	37 (0.3)	21 (0.1)	3 (0.1)	
Meningitis / Encephalitis	82 (0.2)	1 (0.5)	0 (0.0)	12 (0.9)	15 (0.4)	23 (0.4)	9 (0.1)	20 (0.1)	2 (0.0)	
Seizure	545 (1.3)	6 (2.9)	16 (2.9)	24 (1.8)	77 (2.3)	83 (1.4)	152 (1.4)	150 (1.0)	37 (0.7)	
Stroke / Cerebrovascular accident	731 (1.8)	1 (0.5)	7 (1.3)	16 (1.2)	46 (1.4)	117 (2.0)	187 (1.7)	264 (1.8)	93 (1.8)	
Other neurological complication	856 (2.1)	4 (2.0)	8 (1.5)	19 (1.5)	63 (1.9)	90 (1.6)	214 (2.0)	331 (2.3)	127 (2.4)	
Congestive heart failure	2100 (5.0)	0 (0.0)	6 (1.1)	27 (2.1)	78 (2.3)	214 (3.7)	506 (4.7)	913 (6.3)	356 (6.8)	
Endocarditis / Myocarditis	142 (0.3)	2 (1.0)	2 (0.4)	9 (0.7)	18 (0.5)	27 (0.5)	43 (0.4)	39 (0.3)	2 (0.0)	
Pericarditis	97 (0.2)	1 (0.5)	2 (0.4)	6 (0.5)	11 (0.3)	19 (0.3)	26 (0.2)	22 (0.2)	10 (0.2)	
Myocarditis / Pericarditis										

Number of existing comorbidities on admission	Total	Age group (years)							
		19-29	30-39	40-49	50-59	60-69	70-79	80-89	90+
Cardiomyopathy	124 (0.3)	0 (0.0)	2 (0.4)	7 (0.5)	12 (0.4)	18 (0.3)	31 (0.3)	42 (0.3)	12 (0.2)
Cardiac arrhythmia	3097 (7.4)	8 (3.9)	22 (4.1)	74 (5.7)	210 (6.3)	438 (7.6)	824 (7.6)	1128 (7.8)	393 (7.5)
Cardiac ischaemia	738 (1.8)	0 (0.0)	1 (0.2)	11 (0.8)	49 (1.5)	97 (1.7)	204 (1.9)	261 (1.8)	115 (2.2)
Cardiac arrest	1173 (2.8)	1 (0.5)	10 (1.8)	31 (2.4)	99 (3.0)	185 (3.2)	327 (3.0)	377 (2.6)	143 (2.7)
Bloodstream Infection	626 (1.5)	3 (1.5)	12 (2.2)	30 (2.3)	51 (1.5)	109 (1.9)	151 (1.4)	203 (1.4)	67 (1.3)
Coagulation disorder / DIC	1198 (2.9)	5 (2.5)	19 (3.5)	55 (4.2)	161 (4.8)	202 (3.5)	288 (2.7)	361 (2.5)	107 (2.1)
Anaemia	6640 (15.9)	33 (16.2)	97 (17.9)	226 (17.3)	586 (17.5)	991 (17.2)	1692 (15.6)	2232 (15.5)	783 (15.0)
Rhabdomyolysis / Myositis	166 (0.4)	2 (1.0)	3 (0.6)	2 (0.2)	15 (0.4)	18 (0.3)	35 (0.3)	58 (0.4)	33 (0.6)
Acute Kidney Injury	11833 (28.4)	39 (19.1)	126 (23.2)	340 (26.0)	978 (29.3)	1762 (30.6)	3085 (28.4)	4084 (28.3)	1419 (27.3)
Gastrointestinal haemorrhage	581 (1.4)	2 (1.0)	8 (1.5)	12 (0.9)	40 (1.2)	80 (1.4)	141 (1.3)	224 (1.6)	74 (1.4)
Pancreatitis	138 (0.3)	3 (1.5)	10 (1.8)	13 (1.0)	25 (0.7)	26 (0.5)	26 (0.2)	29 (0.2)	6 (0.1)
Deep Vein Thrombosis	228 (0.5)	1 (0.5)	7 (1.3)	5 (0.4)	40 (1.2)	37 (0.6)	52 (0.5)	66 (0.5)	20 (0.4)
Pulmonary Embolism	486 (1.2)	3 (1.5)	4 (0.7)	26 (2.0)	76 (2.3)	101 (1.8)	130 (1.2)	120 (0.8)	26 (0.5)
Liver Injury	3683 (8.8)	22 (10.8)	81 (14.9)	194 (14.9)	530 (15.9)	733 (12.7)	922 (8.5)	915 (6.3)	286 (5.5)

Percentage values are column percentages. ARDS – Acute Respiratory Distress Syndrome, DIC – Disseminated Intravascular Coagulation.

Supplementary table 4 - Outcomes by organ specific complications in adults admitted to hospital with severe COVID-19 who survived.

			Total number of patients experiencing complications		Organ-specific level complications [§]					
			Total patients	Any complication	Systemic	Renal	Gastrointestinal	Cardiovascular	Neurological	Respiratory
Total N (%)			50105	21784 (43.5)	7423 (14.8)	10059 (20.1)	4837 (9.7)	4035 (8.1)	1880 (3.8)	7028 (14.0)
Critical Care Admission	No	43153 (87.4)	16853 (77.4)	5557 (74.9)	7467 (74.3)	3233 (66.9)	3020 (74.8)	1461 (77.7)	3616 (51.5)	
	Yes	6242 (12.6)	4926 (22.6)	1866 (25.1)	2589 (25.7)	1602 (33.1)	1015 (25.2)	419 (22.3)	3410 (48.5)	
Any invasive ventilation	No	45825 (93.0)	18630 (85.6)	6067 (81.8)	8271 (82.3)	3728 (77.2)	3275 (81.2)	1533 (81.5)	4498 (64.0)	
	Yes	3472 (7.0)	3130 (14.4)	1352 (18.2)	1773 (17.7)	1104 (22.8)	758 (18.8)	347 (18.5)	2529 (36.0)	
Any non-invasive ventilation	No	42350 (87.2)	17255 (80.1)	5917 (80.3)	7738 (77.8)	3568 (74.6)	3184 (79.6)	1566 (84.3)	4232 (60.6)	
	Yes	6206 (12.8)	4296 (19.9)	1454 (19.7)	2207 (22.2)	1218 (25.4)	817 (20.4)	291 (15.7)	2748 (39.4)	
Any oxygen	No	15507 (31.8)	4892 (22.6)	1748 (23.7)	1942 (19.4)	940 (19.5)	888 (22.2)	580 (31.1)	627 (8.9)	
	Yes	33310 (68.2)	16760 (77.4)	5642 (76.3)	8061 (80.6)	3873 (80.5)	3120 (77.8)	1285 (68.9)	6379 (91.1)	

Percentage values are column percentages. § = Denominator is number of non-missing observations for each organ system.

Supplementary table 5 - Outcomes by organ specific complications in adults admitted to hospital with severe COVID-19 who died.

Total number of patients experiencing complications			Organ-specific level complications [§]					
	Total	Any complication	Systemic	Renal	Gastrointestinal	Cardiovascular	Neurological	Respiratory
Total N (%)	23092	14583 (63.2)	4472 (19.4)	7693 (33.3)	3064 (13.3)	4938 (21.4)	1235 (5.3)	6458 (28.0)
Critical Care Admission								
No	18972 (83.3)	11239 (77.1)	3247 (72.6)	5525 (71.8)	1906 (62.2)	3620 (73.3)	985 (79.8)	3856 (59.7)
Yes	3792 (16.7)	3341 (22.9)	1224 (27.4)	2166 (28.2)	1158 (37.8)	1318 (26.7)	249 (20.2)	2602 (40.3)
Any invasive ventilation								
No	20063 (88.3)	12080 (82.9)	3489 (78.1)	5991 (77.9)	2087 (68.2)	3911 (79.2)	1040 (84.2)	4311 (66.8)
Yes	2650 (11.7)	2489 (17.1)	978 (21.9)	1698 (22.1)	973 (31.8)	1026 (20.8)	195 (15.8)	2141 (33.2)
Any non-invasive ventilation								
No	17685 (79.3)	10947 (76.1)	3311 (74.8)	5623 (73.9)	2117 (70.0)	3678 (75.1)	1000 (81.8)	4100 (64.2)
Yes	4621 (20.7)	3445 (23.9)	1113 (25.2)	1987 (26.1)	906 (30.0)	1217 (24.9)	222 (18.2)	2290 (35.8)
Any oxygen								
No	2145 (9.5)	1079 (7.4)	331 (7.4)	528 (6.9)	213 (7.0)	302 (6.1)	157 (12.8)	211 (3.3)
Yes	20385 (90.5)	13421 (92.6)	4120 (92.6)	7128 (93.1)	2832 (93.0)	4624 (93.9)	1073 (87.2)	6219 (96.7)

Percentage values are column percentages. § = Denominator is number of non-missing observations for each organ system.

Supplementary table 6 - Effect of complications on survival (adjusted Cox proportional hazards models) for figure 3B

Supplementary table 6A - Any complication

Dependent: Survival (mortality)			HR (univariable)	HR (multivariable)
Any complication	No	37839 (100.0)	-	-
	Yes	36662 (100.0)	1.91 (1.86-1.97, p<0.001)	1.74 (1.64-1.84, p<0.001)
Age on admission	19-29	1477 (100.0)	-	-
	30-39	2707 (100.0)	1.82 (1.25-2.64, p=0.002)	1.68 (1.22-2.31, p=0.002)
	40-49	4930 (100.0)	3.22 (2.29-4.53, p<0.001)	2.78 (1.97-3.94, p<0.001)
	50-59	9003 (100.0)	6.24 (4.48-8.68, p<0.001)	5.26 (3.79-7.29, p<0.001)
	60-69	11035 (100.0)	11.72 (8.43- 16.27, p<0.001)	9.68 (6.99-13.40, p<0.001)
	70-79	16445 (100.0)	18.38 (13.25- 25.51, p<0.001)	15.44 (11.07- 21.54, p<0.001)
	80-89	19771 (100.0)	23.49 (16.93- 32.59, p<0.001)	20.15 (14.56- 27.89, p<0.001)
	90+	7204 (100.0)	27.63 (19.89- 38.36, p<0.001)	24.73 (17.77- 34.40, p<0.001)
	Sex at Birth	Female	31733 (100.0)	-
Male		40648 (100.0)	1.23 (1.20-1.27, p<0.001)	1.30 (1.26-1.33, p<0.001)
Deprivation	1	10347 (100.0)	-	-
	2	12775 (100.0)	1.00 (0.96-1.05, p=0.965)	1.03 (0.97-1.08, p=0.348)
	3	15712 (100.0)	0.99 (0.95-1.04, p=0.743)	1.06 (0.99-1.12, p=0.074)
	4	15880 (100.0)	0.95 (0.91-1.00, p=0.039)	1.07 (1.01-1.13, p=0.033)
	5	17845 (100.0)	0.93 (0.89-0.97, p=0.001)	1.09 (1.03-1.15, p=0.002)

Supplementary table 6B - Systemic complications

Dependent: Survival (mortality)			HR (univariable)	HR (multivariable)
Systemic Complication	No	62531 (100.0)	-	-
	Yes	11970 (100.0)	1.27 (1.23-1.31, p<0.001)	1.20 (1.15-1.26, p<0.001)
Age on admission	19-29	1477 (100.0)	-	-
	30-39	2707 (100.0)	1.82 (1.25-2.64, p=0.002)	1.75 (1.27-2.42, p=0.001)
	40-49	4930 (100.0)	3.22 (2.29-4.53, p<0.001)	3.00 (2.12-4.26, p<0.001)
	50-59	9003 (100.0)	6.24 (4.48-8.68, p<0.001)	5.79 (4.17-8.04, p<0.001)
	60-69	11035 (100.0)	11.72 (8.43- 16.27, p<0.001)	10.87 (7.84- 15.07, p<0.001)
	70-79	16445 (100.0)	18.38 (13.25- 25.51, p<0.001)	17.25 (12.36- 24.09, p<0.001)
	80-89	19771 (100.0)	23.49 (16.93- 32.59, p<0.001)	22.50 (16.24- 31.18, p<0.001)
	90+	7204 (100.0)	27.63 (19.89- 38.36, p<0.001)	27.61 (19.83- 38.43, p<0.001)
	Sex at Birth	Female	31733 (100.0)	-
	Male	40648 (100.0)	1.23 (1.20-1.27, p<0.001)	1.34 (1.30-1.38, p<0.001)
Deprivation	1	10347 (100.0)	-	-
	2	12775 (100.0)	1.00 (0.96-1.05, p=0.965)	1.03 (0.98-1.08, p=0.281)
	3	15712 (100.0)	0.99 (0.95-1.04, p=0.743)	1.06 (1.00-1.12, p=0.059)
	4	15880 (100.0)	0.95 (0.91-1.00, p=0.039)	1.07 (1.02-1.13, p=0.012)
	5	17845 (100.0)	0.93 (0.89-0.97, p=0.001)	1.09 (1.04-1.15, p=0.001)

Supplementary table 6C - Renal complications/ acute kidney injury

Dependent: Survival (mortality)			HR (univariable)	HR (multivariable)
Renal complication	No	56691 (100.0)	-	-
	Yes	17810 (100.0)	1.68 (1.64-1.73, p<0.001)	1.49 (1.42-1.55, p<0.001)
Age on admission	19-29	1477 (100.0)	-	-
	30-39	2707 (100.0)	1.82 (1.25-2.64, p=0.002)	1.74 (1.26-2.39, p=0.001)
	40-49	4930 (100.0)	3.22 (2.29-4.53, p<0.001)	2.92 (2.06-4.14, p<0.001)
	50-59	9003 (100.0)	6.24 (4.48-8.68, p<0.001)	5.53 (3.99-7.68, p<0.001)
	60-69	11035 (100.0)	11.72 (8.43-16.27, p<0.001)	10.22 (7.37-14.17, p<0.001)
	70-79	16445 (100.0)	18.38 (13.25-25.51, p<0.001)	16.24 (11.63-22.67, p<0.001)
	80-89	19771 (100.0)	23.49 (16.93-32.59, p<0.001)	21.16 (15.27-29.32, p<0.001)
	90+	7204 (100.0)	27.63 (19.89-38.36, p<0.001)	26.05 (18.70-36.27, p<0.001)
	Sex at Birth	Female	31733 (100.0)	-
	Male	40648 (100.0)	1.23 (1.20-1.27, p<0.001)	1.31 (1.27-1.35, p<0.001)
Deprivation	1	10347 (100.0)	-	-
	2	12775 (100.0)	1.00 (0.96-1.05, p=0.965)	1.03 (0.98-1.08, p=0.317)
	3	15712 (100.0)	0.99 (0.95-1.04, p=0.743)	1.05 (0.99-1.11, p=0.089)
	4	15880 (100.0)	0.95 (0.91-1.00, p=0.039)	1.06 (1.00-1.12, p=0.046)
	5	17845 (100.0)	0.93 (0.89-0.97, p=0.001)	1.08 (1.02-1.13, p=0.006)

Supplementary table 6D - Gastrointestinal and liver complications

Dependent: Survival (mortality)			HR (univariable)	HR (multivariable)
Gastrointestinal or liver complication	No	66464 (100.0)	-	-
	Yes	8037 (100.0)	1.28 (1.23-1.33, p<0.001)	1.50 (1.44-1.57, p<0.001)
Age on admission	18-29	1477 (100.0)	-	-
	30-39	2707 (100.0)	1.82 (1.25-2.64, p=0.002)	1.74 (1.26-2.39, p=0.001)
	40-49	4930 (100.0)	3.22 (2.29-4.53, p<0.001)	2.97 (2.10-4.20, p<0.001)
	50-59	9003 (100.0)	6.24 (4.48-8.68, p<0.001)	5.71 (4.12-7.92, p<0.001)
	60-69	11035 (100.0)	11.72 (8.43- 16.27, p<0.001)	10.85 (7.84- 15.02, p<0.001)
	70-79	16445 (100.0)	18.38 (13.25- 25.51, p<0.001)	17.54 (12.58- 24.45, p<0.001)
	80-89	19771 (100.0)	23.49 (16.93- 32.59, p<0.001)	23.15 (16.73- 32.03, p<0.001)
	90+	7204 (100.0)	27.63 (19.89- 38.36, p<0.001)	28.46 (20.46- 39.59, p<0.001)
Sex at Birth	Female	31733 (100.0)	-	-
	Male	40648 (100.0)	1.23 (1.20-1.27, p<0.001)	1.33 (1.29-1.37, p<0.001)
Deprivation	1	10347 (100.0)	-	-
	2	12775 (100.0)	1.00 (0.96-1.05, p=0.965)	1.03 (0.98-1.08, p=0.292)
	3	15712 (100.0)	0.99 (0.95-1.04, p=0.743)	1.06 (1.00-1.12, p=0.052)
	4	15880 (100.0)	0.95 (0.91-1.00, p=0.039)	1.08 (1.02-1.14, p=0.011)
	5	17845 (100.0)	0.93 (0.89-0.97, p=0.001)	1.09 (1.04-1.15, p=0.001)

Supplementary table 6E - Cardiovascular complications

Dependent: Survival (mortality)			HR (univariable)	HR (multivariable)
Cardiovascular complication	No	65498 (100.0)	-	-
	Yes	9003 (100.0)	2.32 (2.25-2.39, p<0.001)	1.98 (1.85-2.11, p<0.001)
Age on admission	19-29	1477 (100.0)	-	-
	30-39	2707 (100.0)	1.82 (1.25-2.64, p=0.002)	1.74 (1.26-2.39, p=0.001)
	40-49	4930 (100.0)	3.22 (2.29-4.53, p<0.001)	2.93 (2.07-4.15, p<0.001)
	50-59	9003 (100.0)	6.24 (4.48-8.68, p<0.001)	5.57 (4.02-7.73, p<0.001)
	60-69	11035 (100.0)	11.72 (8.43-16.27, p<0.001)	10.23 (7.38-14.17, p<0.001)
	70-79	16445 (100.0)	18.38 (13.25-25.51, p<0.001)	16.11 (11.55-22.48, p<0.001)
	80-89	19771 (100.0)	23.49 (16.93-32.59, p<0.001)	20.85 (15.05-28.88, p<0.001)
	90+	7204 (100.0)	27.63 (19.89-38.36, p<0.001)	25.50 (18.34-35.45, p<0.001)
	Sex at Birth	Female	31733 (100.0)	-
	Male	40648 (100.0)	1.23 (1.20-1.27, p<0.001)	1.32 (1.28-1.36, p<0.001)
Deprivation	1	10347 (100.0)	-	-
	2	12775 (100.0)	1.00 (0.96-1.05, p=0.965)	1.03 (0.98-1.09, p=0.219)
	3	15712 (100.0)	0.99 (0.95-1.04, p=0.743)	1.06 (1.00-1.12, p=0.053)
	4	15880 (100.0)	0.95 (0.91-1.00, p=0.039)	1.07 (1.02-1.14, p=0.012)
	5	17845 (100.0)	0.93 (0.89-0.97, p=0.001)	1.10 (1.05-1.16, p<0.001)

Supplementary table 6F - Neurological complications

Dependent: Survival (mortality)			HR (univariable)	HR (multivariable)
Neurological complication	No	71340 (100.0)	-	-
	Yes	3161 (100.0)	1.29 (1.22-1.37, p<0.001)	1.21 (1.13-1.29, p<0.001)
Age on admission	19-29	1477 (100.0)	-	-
	30-39	2707 (100.0)	1.82 (1.25-2.64, p=0.002)	1.76 (1.28-2.43, p=0.001)
	40-49	4930 (100.0)	3.22 (2.29-4.53, p<0.001)	3.03 (2.13-4.29, p<0.001)
	50-59	9003 (100.0)	6.24 (4.48-8.68, p<0.001)	5.84 (4.21-8.11, p<0.001)
	60-69	11035 (100.0)	11.72 (8.43-16.27, p<0.001)	10.99 (7.93-15.24, p<0.001)
	70-79	16445 (100.0)	18.38 (13.25-25.51, p<0.001)	17.42 (12.48-24.31, p<0.001)
	80-89	19771 (100.0)	23.49 (16.93-32.59, p<0.001)	22.70 (16.38-31.44, p<0.001)
	90+	7204 (100.0)	27.63 (19.89-38.36, p<0.001)	27.85 (20.00-38.77, p<0.001)
	Sex at Birth	Female	31733 (100.0)	-
	Male	40648 (100.0)	1.23 (1.20-1.27, p<0.001)	1.34 (1.31-1.38, p<0.001)
Deprivation	1	10347 (100.0)	-	-
	2	12775 (100.0)	1.00 (0.96-1.05, p=0.965)	1.03 (0.98-1.08, p=0.287)
	3	15712 (100.0)	0.99 (0.95-1.04, p=0.743)	1.06 (1.00-1.12, p=0.060)
	4	15880 (100.0)	0.95 (0.91-1.00, p=0.039)	1.07 (1.01-1.13, p=0.014)
	5	17845 (100.0)	0.93 (0.89-0.97, p=0.001)	1.09 (1.03-1.14, p=0.001)

Supplementary table 6G - Respiratory complications

Dependent: Survival (mortality)			HR (univariable)	HR (multivariable)
Respiratory complication	No	60982 (100.0)	-	-
	Yes	13519 (100.0)	1.89 (1.83-1.94, p<0.001)	2.15 (2.04-2.27, p<0.001)
Age on admission	19-29	1477 (100.0)	-	-
	30-39	2707 (100.0)	1.82 (1.25-2.64, p=0.002)	1.65 (1.20-2.27, p=0.002)
	40-49	4930 (100.0)	3.22 (2.29-4.53, p<0.001)	2.67 (1.89-3.78, p<0.001)
	50-59	9003 (100.0)	6.24 (4.48-8.68, p<0.001)	5.12 (3.70-7.10, p<0.001)
	60-69	11035 (100.0)	11.72 (8.43-16.27, p<0.001)	9.71 (7.01-13.45, p<0.001)
	70-79	16445 (100.0)	18.38 (13.25-25.51, p<0.001)	16.45 (11.80-22.92, p<0.001)
	80-89	19771 (100.0)	23.49 (16.93-32.59, p<0.001)	22.33 (16.15-30.89, p<0.001)
	90+	7204 (100.0)	27.63 (19.89-38.36, p<0.001)	27.49 (19.78-38.21, p<0.001)
	Sex at Birth	Female	31733 (100.0)	-
	Male	40648 (100.0)	1.23 (1.20-1.27, p<0.001)	1.31 (1.27-1.35, p<0.001)
Deprivation	1	10347 (100.0)	-	-
	2	12775 (100.0)	1.00 (0.96-1.05, p=0.965)	1.03 (0.98-1.08, p=0.209)
	3	15712 (100.0)	0.99 (0.95-1.04, p=0.743)	1.05 (0.99-1.11, p=0.135)
	4	15880 (100.0)	0.95 (0.91-1.00, p=0.039)	1.07 (1.01-1.13, p=0.022)
	5	17845 (100.0)	0.93 (0.89-0.97, p=0.001)	1.10 (1.04-1.16, p<0.001)

Effect of complications on odds of critical care admission (adjusted logistic regression models) for figure 3C

Supplementary table 6H - Any complication

Dependent: Critical Care Admission		No	Yes	OR (univariable)	OR (multilevel)
Any complication	No	33809 (95.1)	1760 (4.9)	-	-
	Yes	27937 (77.4)	8155 (22.6)	5.61 (5.31- 5.92, p<0.001)	7.25 (6.83- 7.69, p<0.001)
Age on admission	19-29	1241 (85.8)	205 (14.2)	-	-
	30-39	2101 (79.1)	555 (20.9)	1.60 (1.34- 1.91, p<0.001)	1.33 (1.10- 1.61, p=0.004)
	40-49	3596 (74.0)	1264 (26.0)	2.13 (1.82- 2.51, p<0.001)	1.57 (1.32- 1.88, p<0.001)
	50-59	6389 (71.7)	2521 (28.3)	2.39 (2.05- 2.80, p<0.001)	1.63 (1.38- 1.94, p<0.001)
	60-69	8166 (74.9)	2740 (25.1)	2.03 (1.75- 2.38, p<0.001)	1.24 (1.04- 1.47, p=0.014)
	70-79	14285 (87.9)	1960 (12.1)	0.83 (0.71- 0.97, p=0.019)	0.47 (0.39- 0.56, p<0.001)
	80-89	18964 (97.1)	567 (2.9)	0.18 (0.15- 0.21, p<0.001)	0.10 (0.08- 0.12, p<0.001)
	90+	7004 (98.6)	103 (1.4)	0.09 (0.07- 0.11, p<0.001)	0.05 (0.04- 0.07, p<0.001)
Sex at Birth	Female	28230 (90.1)	3100 (9.9)	-	-
	Male	33348 (83.1)	6792 (16.9)	1.85 (1.77- 1.94, p<0.001)	1.49 (1.42- 1.57, p<0.001)
Deprivation	1	8747 (86.2)	1401 (13.8)	-	-
	2	10923 (86.9)	1653 (13.1)	0.94 (0.88- 1.02, p=0.146)	0.86 (0.79- 0.94, p=0.001)
	3	13352 (86.3)	2115 (13.7)	0.99 (0.92- 1.06, p=0.765)	0.89 (0.82- 0.98, p=0.012)
	4	13360 (85.1)	2340 (14.9)	1.09 (1.02- 1.17, p=0.014)	0.89 (0.82- 0.97, p=0.011)
	5	15352 (86.5)	2405 (13.5)	0.98 (0.91- 1.05, p=0.540)	0.78 (0.72- 0.85, p<0.001)

Supplementary table 6I - Systemic complications

Dependent: Critical Care Admission		No	Yes	OR (univariable)	OR (multilevel)
Systemic complication	No	53004 (88.5)	6875 (11.5)	-	-
	Yes	8742 (74.2)	3040 (25.8)	2.68 (2.55- 2.81, p<0.001)	3.15 (2.97- 3.33, p<0.001)
Age on admission	19-29	1241 (85.8)	205 (14.2)	-	-
	30-39	2101 (79.1)	555 (20.9)	1.60 (1.34- 1.91, p<0.001)	1.45 (1.21- 1.74, p<0.001)
	40-49	3596 (74.0)	1264 (26.0)	2.13 (1.82- 2.51, p<0.001)	1.84 (1.56- 2.18, p<0.001)
	50-59	6389 (71.7)	2521 (28.3)	2.39 (2.05- 2.80, p<0.001)	2.05 (1.74- 2.41, p<0.001)
	60-69	8166 (74.9)	2740 (25.1)	2.03 (1.75- 2.38, p<0.001)	1.70 (1.45- 2.00, p<0.001)
	70-79	14285 (87.9)	1960 (12.1)	0.83 (0.71- 0.97, p=0.019)	0.69 (0.58- 0.81, p<0.001)
	80-89	18964 (97.1)	567 (2.9)	0.18 (0.15- 0.21, p<0.001)	0.15 (0.13- 0.18, p<0.001)
	90+	7004 (98.6)	103 (1.4)	0.09 (0.07- 0.11, p<0.001)	0.08 (0.06- 0.10, p<0.001)
	Sex at Birth	Female	28230 (90.1)	3100 (9.9)	-
Male		33348 (83.1)	6792 (16.9)	1.85 (1.77- 1.94, p<0.001)	1.65 (1.58- 1.74, p<0.001)
Deprivation	1	8747 (86.2)	1401 (13.8)	-	-
	2	10923 (86.9)	1653 (13.1)	0.94 (0.88- 1.02, p=0.146)	0.88 (0.81- 0.96, p=0.005)
	3	13352 (86.3)	2115 (13.7)	0.99 (0.92- 1.06, p=0.765)	0.90 (0.83- 0.98, p=0.020)
	4	13360 (85.1)	2340 (14.9)	1.09 (1.02- 1.17, p=0.014)	0.91 (0.84- 0.99, p=0.035)
	5	15352 (86.5)	2405 (13.5)	0.98 (0.91- 1.05, p=0.540)	0.82 (0.75- 0.89, p<0.001)

Supplementary table 6J - Renal complications/ acute kidney injury

Dependent: Critical Care Admission		No	Yes	OR (univariable)	OR (multilevel)
Renal complication	No	48812 (90.3)	5238 (9.7)	-	-
	Yes	12934 (73.4)	4677 (26.6)	3.37 (3.22- 3.52, p<0.001)	4.36 (4.14- 4.58, p<0.001)
Age on admission	19-29	1241 (85.8)	205 (14.2)	-	-
	30-39	2101 (79.1)	555 (20.9)	1.60 (1.34- 1.91, p<0.001)	1.45 (1.21- 1.74, p<0.001)
	40-49	3596 (74.0)	1264 (26.0)	2.13 (1.82- 2.51, p<0.001)	1.74 (1.47- 2.06, p<0.001)
	50-59	6389 (71.7)	2521 (28.3)	2.39 (2.05- 2.80, p<0.001)	1.82 (1.54- 2.14, p<0.001)
	60-69	8166 (74.9)	2740 (25.1)	2.03 (1.75- 2.38, p<0.001)	1.40 (1.19- 1.65, p<0.001)
	70-79	14285 (87.9)	1960 (12.1)	0.83 (0.71- 0.97, p=0.019)	0.54 (0.46- 0.64, p<0.001)
	80-89	18964 (97.1)	567 (2.9)	0.18 (0.15- 0.21, p<0.001)	0.11 (0.10- 0.14, p<0.001)
	90+	7004 (98.6)	103 (1.4)	0.09 (0.07- 0.11, p<0.001)	0.06 (0.05- 0.07, p<0.001)
	Sex at Birth	Female	28230 (90.1)	3100 (9.9)	-
Male		33348 (83.1)	6792 (16.9)	1.85 (1.77- 1.94, p<0.001)	1.51 (1.44- 1.59, p<0.001)
Deprivation	1	8747 (86.2)	1401 (13.8)	-	-
	2	10923 (86.9)	1653 (13.1)	0.94 (0.88- 1.02, p=0.146)	0.89 (0.81- 0.97, p=0.009)
	3	13352 (86.3)	2115 (13.7)	0.99 (0.92- 1.06, p=0.765)	0.89 (0.82- 0.97, p=0.011)
	4	13360 (85.1)	2340 (14.9)	1.09 (1.02- 1.17, p=0.014)	0.89 (0.81- 0.97, p=0.006)
	5	15352 (86.5)	2405 (13.5)	0.98 (0.91- 1.05, p=0.540)	0.79 (0.73- 0.86, p<0.001)

Supplementary table 6K - Gastrointestinal and liver complications

Dependent: Critical Care Admission		No	Yes	OR (univariable)	OR (multilevel)
Gastrointestinal or liver complication	No	56625 (88.8)	7173 (11.2)	-	-
	Yes	5121 (65.1)	2742 (34.9)	4.23 (4.01- 4.45, p<0.001)	3.52 (3.32- 3.74, p<0.001)
Age on admission	19-29	1241 (85.8)	205 (14.2)	-	-
	30-39	2101 (79.1)	555 (20.9)	1.60 (1.34- 1.91, p<0.001)	1.45 (1.21- 1.75, p<0.001)
	40-49	3596 (74.0)	1264 (26.0)	2.13 (1.82- 2.51, p<0.001)	1.84 (1.56- 2.19, p<0.001)
	50-59	6389 (71.7)	2521 (28.3)	2.39 (2.05- 2.80, p<0.001)	2.08 (1.77- 2.45, p<0.001)
	60-69	8166 (74.9)	2740 (25.1)	2.03 (1.75- 2.38, p<0.001)	1.82 (1.55- 2.14, p<0.001)
	70-79	14285 (87.9)	1960 (12.1)	0.83 (0.71- 0.97, p=0.019)	0.77 (0.65- 0.90, p=0.001)
	80-89	18964 (97.1)	567 (2.9)	0.18 (0.15- 0.21, p<0.001)	0.18 (0.15- 0.21, p<0.001)
	90+	7004 (98.6)	103 (1.4)	0.09 (0.07- 0.11, p<0.001)	0.09 (0.07- 0.12, p<0.001)
	Sex at Birth	Female	28230 (90.1)	3100 (9.9)	-
Male		33348 (83.1)	6792 (16.9)	1.85 (1.77- 1.94, p<0.001)	1.56 (1.48- 1.63, p<0.001)
Deprivation	1	8747 (86.2)	1401 (13.8)	-	-
	2	10923 (86.9)	1653 (13.1)	0.94 (0.88- 1.02, p=0.146)	0.89 (0.82- 0.97, p=0.009)
	3	13352 (86.3)	2115 (13.7)	0.99 (0.92- 1.06, p=0.765)	0.93 (0.86- 1.01, p=0.096)
	4	13360 (85.1)	2340 (14.9)	1.09 (1.02- 1.17, p=0.014)	0.94 (0.87- 1.03, p=0.170)
	5	15352 (86.5)	2405 (13.5)	0.98 (0.91- 1.05, p=0.540)	0.85 (0.78- 0.92, p<0.001)

Supplementary table 6L - Cardiovascular complications

Dependent: Critical Care Admission		No	Yes	OR (univariable)	OR (multilevel)
Cardiovascular complication	No	55139 (87.9)	7619 (12.1)	-	-
	Yes	6607 (74.2)	2296 (25.8)	2.51 (2.38- 2.65, p<0.001)	3.64 (3.42- 3.88, p<0.001)
Age on admission	19-29	1241 (85.8)	205 (14.2)	-	-
	30-39	2101 (79.1)	555 (20.9)	1.60 (1.34- 1.91, p<0.001)	1.48 (1.24- 1.78, p<0.001)
	40-49	3596 (74.0)	1264 (26.0)	2.13 (1.82- 2.51, p<0.001)	1.83 (1.54- 2.16, p<0.001)
	50-59	6389 (71.7)	2521 (28.3)	2.39 (2.05- 2.80, p<0.001)	2.02 (1.72- 2.37, p<0.001)
	60-69	8166 (74.9)	2740 (25.1)	2.03 (1.75- 2.38, p<0.001)	1.63 (1.39- 1.91, p<0.001)
	70-79	14285 (87.9)	1960 (12.1)	0.83 (0.71- 0.97, p=0.019)	0.63 (0.53- 0.74, p<0.001)
	80-89	18964 (97.1)	567 (2.9)	0.18 (0.15- 0.21, p<0.001)	0.13 (0.11- 0.16, p<0.001)
	90+	7004 (98.6)	103 (1.4)	0.09 (0.07- 0.11, p<0.001)	0.07 (0.05- 0.09, p<0.001)
	Sex at Birth	Female	28230 (90.1)	3100 (9.9)	-
Male		33348 (83.1)	6792 (16.9)	1.85 (1.77- 1.94, p<0.001)	1.61 (1.53- 1.69, p<0.001)
Deprivation	1	8747 (86.2)	1401 (13.8)	-	-
	2	10923 (86.9)	1653 (13.1)	0.94 (0.88- 1.02, p=0.146)	0.89 (0.81- 0.97, p=0.006)
	3	13352 (86.3)	2115 (13.7)	0.99 (0.92- 1.06, p=0.765)	0.92 (0.84- 1.00, p=0.046)
	4	13360 (85.1)	2340 (14.9)	1.09 (1.02- 1.17, p=0.014)	0.92 (0.85- 1.00, p=0.050)
	5	15352 (86.5)	2405 (13.5)	0.98 (0.91- 1.05, p=0.540)	0.83 (0.76- 0.90, p<0.001)

Supplementary table 6M - Neurological complications

Dependent: Critical Care Admission		No	Yes	OR (univariable)	OR (multilevel)
Neurological complication	No	59321 (86.5)	9264 (13.5)	-	-
	Yes	2425 (78.8)	651 (21.2)	1.72 (1.57- 1.88, p<0.001)	1.88 (1.70- 2.08, p<0.001)
Age on admission	19-29	1241 (85.8)	205 (14.2)	-	-
	30-39	2101 (79.1)	555 (20.9)	1.60 (1.34- 1.91, p<0.001)	1.51 (1.26- 1.81, p<0.001)
	40-49	3596 (74.0)	1264 (26.0)	2.13 (1.82- 2.51, p<0.001)	1.91 (1.62- 2.26, p<0.001)
	50-59	6389 (71.7)	2521 (28.3)	2.39 (2.05- 2.80, p<0.001)	2.17 (1.85- 2.55, p<0.001)
	60-69	8166 (74.9)	2740 (25.1)	2.03 (1.75- 2.38, p<0.001)	1.85 (1.58- 2.17, p<0.001)
	70-79	14285 (87.9)	1960 (12.1)	0.83 (0.71- 0.97, p=0.019)	0.75 (0.64- 0.88, p<0.001)
	80-89	18964 (97.1)	567 (2.9)	0.18 (0.15- 0.21, p<0.001)	0.17 (0.14- 0.20, p<0.001)
	90+	7004 (98.6)	103 (1.4)	0.09 (0.07- 0.11, p<0.001)	0.09 (0.07- 0.11, p<0.001)
	Sex at Birth	Female	28230 (90.1)	3100 (9.9)	-
Male		33348 (83.1)	6792 (16.9)	1.85 (1.77- 1.94, p<0.001)	1.65 (1.57- 1.73, p<0.001)
Deprivation	1	8747 (86.2)	1401 (13.8)	-	-
	2	10923 (86.9)	1653 (13.1)	0.94 (0.88- 1.02, p=0.146)	0.90 (0.82- 0.97, p=0.010)
	3	13352 (86.3)	2115 (13.7)	0.99 (0.92- 1.06, p=0.765)	0.92 (0.85- 1.00, p=0.065)
	4	13360 (85.1)	2340 (14.9)	1.09 (1.02- 1.17, p=0.014)	0.94 (0.86- 1.02, p=0.114)
	5	15352 (86.5)	2405 (13.5)	0.98 (0.91- 1.05, p=0.540)	0.83 (0.77- 0.91, p<0.001)

Supplementary table 6N - Respiratory complications

Dependent: Critical Care Admission		No	Yes	OR (univariable)	OR (multilevel)
Respiratory complication	No	54321 (93.2)	3986 (6.8)	-	-
	Yes	7425 (55.6)	5929 (44.4)	10.88 (10.38- 11.41, p<0.001)	12.48 (11.81- 13.18, p<0.001)
Age on admission	19-29	1241 (85.8)	205 (14.2)	-	-
	30-39	2101 (79.1)	555 (20.9)	1.60 (1.34- 1.91, p<0.001)	1.28 (1.05- 1.56, p=0.015)
	40-49	3596 (74.0)	1264 (26.0)	2.13 (1.82- 2.51, p<0.001)	1.40 (1.17- 1.68, p<0.001)
	50-59	6389 (71.7)	2521 (28.3)	2.39 (2.05- 2.80, p<0.001)	1.56 (1.31- 1.86, p<0.001)
	60-69	8166 (74.9)	2740 (25.1)	2.03 (1.75- 2.38, p<0.001)	1.27 (1.06- 1.51, p=0.008)
	70-79	14285 (87.9)	1960 (12.1)	0.83 (0.71- 0.97, p=0.019)	0.52 (0.44- 0.62, p<0.001)
	80-89	18964 (97.1)	567 (2.9)	0.18 (0.15- 0.21, p<0.001)	0.11 (0.09- 0.14, p<0.001)
	90+	7004 (98.6)	103 (1.4)	0.09 (0.07- 0.11, p<0.001)	0.06 (0.04- 0.08, p<0.001)
Sex at Birth	Female	28230 (90.1)	3100 (9.9)	-	-
	Male	33348 (83.1)	6792 (16.9)	1.85 (1.77- 1.94, p<0.001)	1.53 (1.44- 1.61, p<0.001)
Deprivation	1	8747 (86.2)	1401 (13.8)	-	-
	2	10923 (86.9)	1653 (13.1)	0.94 (0.88- 1.02, p=0.146)	0.86 (0.79- 0.95, p=0.003)
	3	13352 (86.3)	2115 (13.7)	0.99 (0.92- 1.06, p=0.765)	0.90 (0.82- 0.99, p=0.029)
	4	13360 (85.1)	2340 (14.9)	1.09 (1.02- 1.17, p=0.014)	0.88 (0.81- 0.97, p=0.009)
	5	15352 (86.5)	2405 (13.5)	0.98 (0.91- 1.05, p=0.540)	0.80 (0.73- 0.88, p<0.001)

Supplementary table 7 - Effect of complications on odds of worse ability to self-care at discharge (adjusted logistic regression models) for figure 5

Supplementary table 7A - Any complication

Dependent: Worse self- care ability		Equivalent to admission	Worse	OR (univariable)	OR (multilevel)
Any complication	No	19507 (88.1)	2636 (11.9)	-	-
	Yes	12115 (74.9)	4067 (25.1)	2.48 (2.35- 2.62, p<0.001)	2.47 (2.33- 2.61, p<0.001)
Age on admission	19-29	1121 (95.4)	54 (4.6)	-	-
	30-39	1962 (91.6)	179 (8.4)	1.89 (1.39- 2.61, p<0.001)	1.83 (1.33- 2.52, p<0.001)
	40-49	3331 (89.0)	411 (11.0)	2.56 (1.93- 3.46, p<0.001)	2.35 (1.74- 3.16, p<0.001)
	50-59	5508 (87.6)	783 (12.4)	2.95 (2.25- 3.96, p<0.001)	2.71 (2.03- 3.62, p<0.001)
	60-69	5451 (84.4)	1010 (15.6)	3.85 (2.93- 5.15, p<0.001)	3.45 (2.59- 4.60, p<0.001)
	70-79	6239 (79.1)	1649 (20.9)	5.49 (4.20- 7.33, p<0.001)	4.96 (3.73- 6.58, p<0.001)
	80-89	6069 (76.0)	1920 (24.0)	6.57 (5.03- 8.77, p<0.001)	5.94 (4.47- 7.88, p<0.001)
	90+	1941 (73.6)	697 (26.4)	7.45 (5.65- 10.03, p<0.001)	6.98 (5.20- 9.35, p<0.001)
	Sex at Birth	Female	14445 (82.6)	3047 (17.4)	-
Male		17095 (82.4)	3639 (17.6)	1.01 (0.96- 1.06, p=0.736)	1.01 (0.96- 1.07, p=0.634)
Deprivation	1	4457 (81.7)	995 (18.3)	-	-
	2	5450 (81.3)	1254 (18.7)	1.03 (0.94- 1.13, p=0.520)	0.99 (0.90- 1.10, p=0.867)
	3	6708 (81.9)	1485 (18.1)	0.99 (0.91- 1.08, p=0.853)	1.02 (0.93- 1.13, p=0.636)
	4	6907 (82.2)	1494 (17.8)	0.97 (0.89- 1.06, p=0.485)	1.05 (0.95- 1.16, p=0.369)
	5	8090 (84.6)	1475 (15.4)	0.82 (0.75- 0.89, p<0.001)	0.94 (0.85- 1.04, p=0.205)

Supplementary table 7B - Systemic complications

Dependent: Worse self- care ability		Equivalent to admission	Worse	OR (univariable)	OR (multilevel)
Systemic complication	No	26184 (84.4)	4840 (15.6)	-	-
	Yes	3785 (70.2)	1606 (29.8)	2.30 (2.15- 2.45, p<0.001)	2.30 (2.14- 2.47, p<0.001)
Age on admission	19-29	1121 (95.4)	54 (4.6)	-	-
	30-39	1962 (91.6)	179 (8.4)	1.89 (1.39- 2.61, p<0.001)	1.85 (1.34- 2.56, p<0.001)
	40-49	3331 (89.0)	411 (11.0)	2.56 (1.93- 3.46, p<0.001)	2.48 (1.83- 3.35, p<0.001)
	50-59	5508 (87.6)	783 (12.4)	2.95 (2.25- 3.96, p<0.001)	2.89 (2.16- 3.88, p<0.001)
	60-69	5451 (84.4)	1010 (15.6)	3.85 (2.93- 5.15, p<0.001)	3.67 (2.74- 4.92, p<0.001)
	70-79	6239 (79.1)	1649 (20.9)	5.49 (4.20- 7.33, p<0.001)	5.31 (3.98- 7.09, p<0.001)
	80-89	6069 (76.0)	1920 (24.0)	6.57 (5.03- 8.77, p<0.001)	6.34 (4.75- 8.45, p<0.001)
	90+	1941 (73.6)	697 (26.4)	7.45 (5.65- 10.03, p<0.001)	7.33 (5.44- 9.88, p<0.001)
Sex at Birth	Female	14445 (82.6)	3047 (17.4)	-	-
	Male	17095 (82.4)	3639 (17.6)	1.01 (0.96- 1.06, p=0.736)	1.06 (1.00- 1.12, p=0.060)
Deprivation	1	4457 (81.7)	995 (18.3)	-	-
	2	5450 (81.3)	1254 (18.7)	1.03 (0.94- 1.13, p=0.520)	1.00 (0.91- 1.11, p=0.943)
	3	6708 (81.9)	1485 (18.1)	0.99 (0.91- 1.08, p=0.853)	1.03 (0.93- 1.14, p=0.526)
	4	6907 (82.2)	1494 (17.8)	0.97 (0.89- 1.06, p=0.485)	1.07 (0.96- 1.18, p=0.213)
	5	8090 (84.6)	1475 (15.4)	0.82 (0.75- 0.89, p<0.001)	0.95 (0.86- 1.05, p=0.336)

Supplementary table 7C - Renal complications/ acute kidney injury

Dependent: Worse self- care ability		Equivalent to admission	Worse	OR (univariable)	OR (multilevel)
Renal complication	No	25682 (84.8)	4587 (15.2)	-	-
	Yes	5271 (72.4)	2009 (27.6)	2.13 (2.01- 2.27, p<0.001)	2.05 (1.92- 2.19, p<0.001)
Age on admission	19-29	1121 (95.4)	54 (4.6)	-	-
	30-39	1962 (91.6)	179 (8.4)	1.89 (1.39- 2.61, p<0.001)	1.86 (1.35- 2.57, p<0.001)
	40-49	3331 (89.0)	411 (11.0)	2.56 (1.93- 3.46, p<0.001)	2.45 (1.82- 3.31, p<0.001)
	50-59	5508 (87.6)	783 (12.4)	2.95 (2.25- 3.96, p<0.001)	2.78 (2.07- 3.71, p<0.001)
	60-69	5451 (84.4)	1010 (15.6)	3.85 (2.93- 5.15, p<0.001)	3.53 (2.64- 4.71, p<0.001)
	70-79	6239 (79.1)	1649 (20.9)	5.49 (4.20- 7.33, p<0.001)	5.02 (3.77- 6.69, p<0.001)
	80-89	6069 (76.0)	1920 (24.0)	6.57 (5.03- 8.77, p<0.001)	6.01 (4.51- 8.00, p<0.001)
	90+	1941 (73.6)	697 (26.4)	7.45 (5.65- 10.03, p<0.001)	6.98 (5.19- 9.38, p<0.001)
Sex at Birth	Female	14445 (82.6)	3047 (17.4)	-	-
	Male	17095 (82.4)	3639 (17.6)	1.01 (0.96- 1.06, p=0.736)	1.02 (0.96- 1.08, p=0.528)
Deprivation	1	4457 (81.7)	995 (18.3)	-	-
	2	5450 (81.3)	1254 (18.7)	1.03 (0.94- 1.13, p=0.520)	0.99 (0.89- 1.09, p=0.803)
	3	6708 (81.9)	1485 (18.1)	0.99 (0.91- 1.08, p=0.853)	1.02 (0.92- 1.12, p=0.764)
	4	6907 (82.2)	1494 (17.8)	0.97 (0.89- 1.06, p=0.485)	1.04 (0.94- 1.15, p=0.486)
	5	8090 (84.6)	1475 (15.4)	0.82 (0.75- 0.89, p<0.001)	0.93 (0.84- 1.03, p=0.164)

Supplementary table 7D - Gastrointestinal and liver complications

Dependent: Worse self-care ability		Equivalent to admission	Worse	OR (univariable)	OR (multilevel)
Gastrointestinal or liver complication	No	28901 (83.2)	5830 (16.8)	-	-
	Yes	2721 (75.7)	873 (24.3)	1.59 (1.47-1.72, p<0.001)	1.93 (1.76-2.11, p<0.001)
Age on admission	19-29	1121 (95.4)	54 (4.6)	-	-
	30-39	1962 (91.6)	179 (8.4)	1.89 (1.39-2.61, p<0.001)	1.85 (1.35-2.55, p<0.001)
	40-49	3331 (89.0)	411 (11.0)	2.56 (1.93-3.46, p<0.001)	2.48 (1.85-3.33, p<0.001)
	50-59	5508 (87.6)	783 (12.4)	2.95 (2.25-3.96, p<0.001)	2.94 (2.21-3.92, p<0.001)
	60-69	5451 (84.4)	1010 (15.6)	3.85 (2.93-5.15, p<0.001)	3.89 (2.93-5.18, p<0.001)
	70-79	6239 (79.1)	1649 (20.9)	5.49 (4.20-7.33, p<0.001)	5.74 (4.33-7.60, p<0.001)
	80-89	6069 (76.0)	1920 (24.0)	6.57 (5.03-8.77, p<0.001)	6.94 (5.24-9.20, p<0.001)
	90+	1941 (73.6)	697 (26.4)	7.45 (5.65-10.03, p<0.001)	8.12 (6.07-10.87, p<0.001)
Sex at Birth	Female	14445 (82.6)	3047 (17.4)	-	-
	Male	17095 (82.4)	3639 (17.6)	1.01 (0.96-1.06, p=0.736)	1.04 (0.99-1.11, p=0.128)
Deprivation	1	4457 (81.7)	995 (18.3)	-	-
	2	5450 (81.3)	1254 (18.7)	1.03 (0.94-1.13, p=0.520)	0.99 (0.90-1.09, p=0.828)
	3	6708 (81.9)	1485 (18.1)	0.99 (0.91-1.08, p=0.853)	1.04 (0.94-1.15, p=0.443)
	4	6907 (82.2)	1494 (17.8)	0.97 (0.89-1.06, p=0.485)	1.07 (0.97-1.19, p=0.160)
	5	8090 (84.6)	1475 (15.4)	0.82 (0.75-0.89, p<0.001)	0.96 (0.86-1.06, p=0.390)

Supplementary table 7E - Cardiovascular complications

Dependent: Worse self- care ability		Equivalent to admission	Worse	OR (univariable)	OR (multilevel)
Cardiovascular complication	No	28053 (83.6)	5510 (16.4)	-	-
	Yes	1943 (67.5)	934 (32.5)	2.45 (2.25- 2.66, p<0.001)	2.16 (1.98- 2.37, p<0.001)
Age on admission	19-29	1121 (95.4)	54 (4.6)	-	-
	30-39	1962 (91.6)	179 (8.4)	1.89 (1.39- 2.61, p<0.001)	1.87 (1.35- 2.58, p<0.001)
	40-49	3331 (89.0)	411 (11.0)	2.56 (1.93- 3.46, p<0.001)	2.45 (1.82- 3.32, p<0.001)
	50-59	5508 (87.6)	783 (12.4)	2.95 (2.25- 3.96, p<0.001)	2.85 (2.13- 3.82, p<0.001)
	60-69	5451 (84.4)	1010 (15.6)	3.85 (2.93- 5.15, p<0.001)	3.62 (2.71- 4.84, p<0.001)
	70-79	6239 (79.1)	1649 (20.9)	5.49 (4.20- 7.33, p<0.001)	5.24 (3.93- 6.98, p<0.001)
	80-89	6069 (76.0)	1920 (24.0)	6.57 (5.03- 8.77, p<0.001)	6.21 (4.66- 8.28, p<0.001)
	90+	1941 (73.6)	697 (26.4)	7.45 (5.65- 10.03, p<0.001)	7.11 (5.28- 9.56, p<0.001)
	Sex at Birth	Female	14445 (82.6)	3047 (17.4)	-
Male		17095 (82.4)	3639 (17.6)	1.01 (0.96- 1.06, p=0.736)	1.05 (0.99- 1.11, p=0.097)
Deprivation	1	4457 (81.7)	995 (18.3)	-	-
	2	5450 (81.3)	1254 (18.7)	1.03 (0.94- 1.13, p=0.520)	0.99 (0.90- 1.10, p=0.904)
	3	6708 (81.9)	1485 (18.1)	0.99 (0.91- 1.08, p=0.853)	1.03 (0.93- 1.14, p=0.525)
	4	6907 (82.2)	1494 (17.8)	0.97 (0.89- 1.06, p=0.485)	1.06 (0.96- 1.17, p=0.256)
	5	8090 (84.6)	1475 (15.4)	0.82 (0.75- 0.89, p<0.001)	0.95 (0.86- 1.05, p=0.318)

Supplementary table 7F - Neurological complications

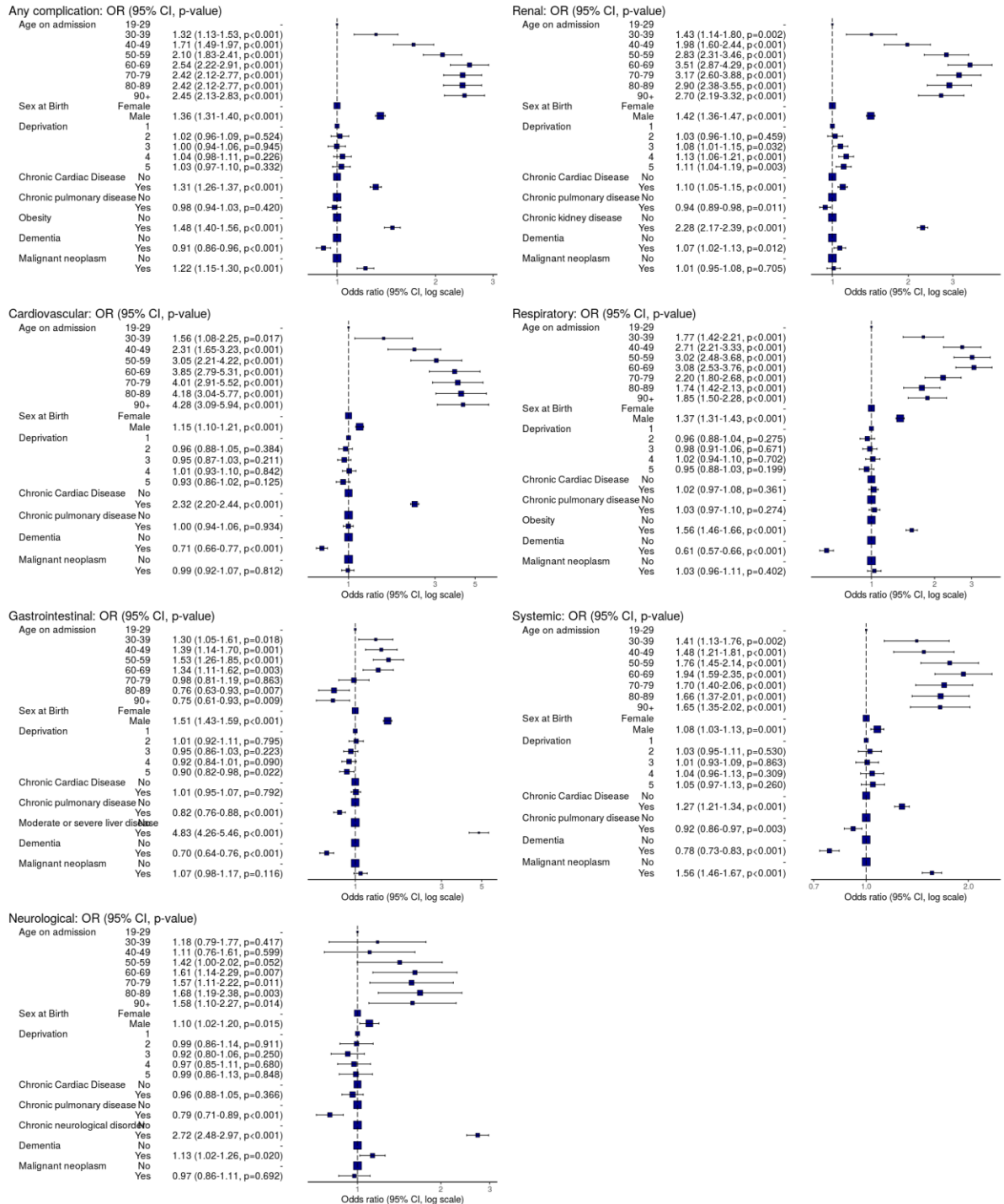
Dependent: Worse self- care ability		Equivalent to admission	Worse	OR (univariable)	OR (multilevel)
Neurological complication	No	29289 (83.3)	5882 (16.7)	-	-
	Yes	640 (54.1)	542 (45.9)	4.22 (3.75- 4.74, p<0.001)	4.08 (3.59- 4.63, p<0.001)
Age on admission	19-29	1121 (95.4)	54 (4.6)	-	-
	30-39	1962 (91.6)	179 (8.4)	1.89 (1.39- 2.61, p<0.001)	1.87 (1.35- 2.59, p<0.001)
	40-49	3331 (89.0)	411 (11.0)	2.56 (1.93- 3.46, p<0.001)	2.47 (1.82- 3.34, p<0.001)
	50-59	5508 (87.6)	783 (12.4)	2.95 (2.25- 3.96, p<0.001)	2.89 (2.15- 3.88, p<0.001)
	60-69	5451 (84.4)	1010 (15.6)	3.85 (2.93- 5.15, p<0.001)	3.74 (2.79- 5.00, p<0.001)
	70-79	6239 (79.1)	1649 (20.9)	5.49 (4.20- 7.33, p<0.001)	5.42 (4.06- 7.24, p<0.001)
	80-89	6069 (76.0)	1920 (24.0)	6.57 (5.03- 8.77, p<0.001)	6.42 (4.81- 8.57, p<0.001)
	90+	1941 (73.6)	697 (26.4)	7.45 (5.65- 10.03, p<0.001)	7.41 (5.49- 9.99, p<0.001)
Sex at Birth	Female	14445 (82.6)	3047 (17.4)	-	-
	Male	17095 (82.4)	3639 (17.6)	1.01 (0.96- 1.06, p=0.736)	1.05 (0.99- 1.12, p=0.080)
Deprivation	1	4457 (81.7)	995 (18.3)	-	-
	2	5450 (81.3)	1254 (18.7)	1.03 (0.94- 1.13, p=0.520)	1.01 (0.91- 1.11, p=0.923)
	3	6708 (81.9)	1485 (18.1)	0.99 (0.91- 1.08, p=0.853)	1.04 (0.94- 1.16, p=0.400)
	4	6907 (82.2)	1494 (17.8)	0.97 (0.89- 1.06, p=0.485)	1.08 (0.98- 1.20, p=0.138)
	5	8090 (84.6)	1475 (15.4)	0.82 (0.75- 0.89, p<0.001)	0.95 (0.86- 1.06, p=0.358)

Supplementary table 7G - Respiratory complications

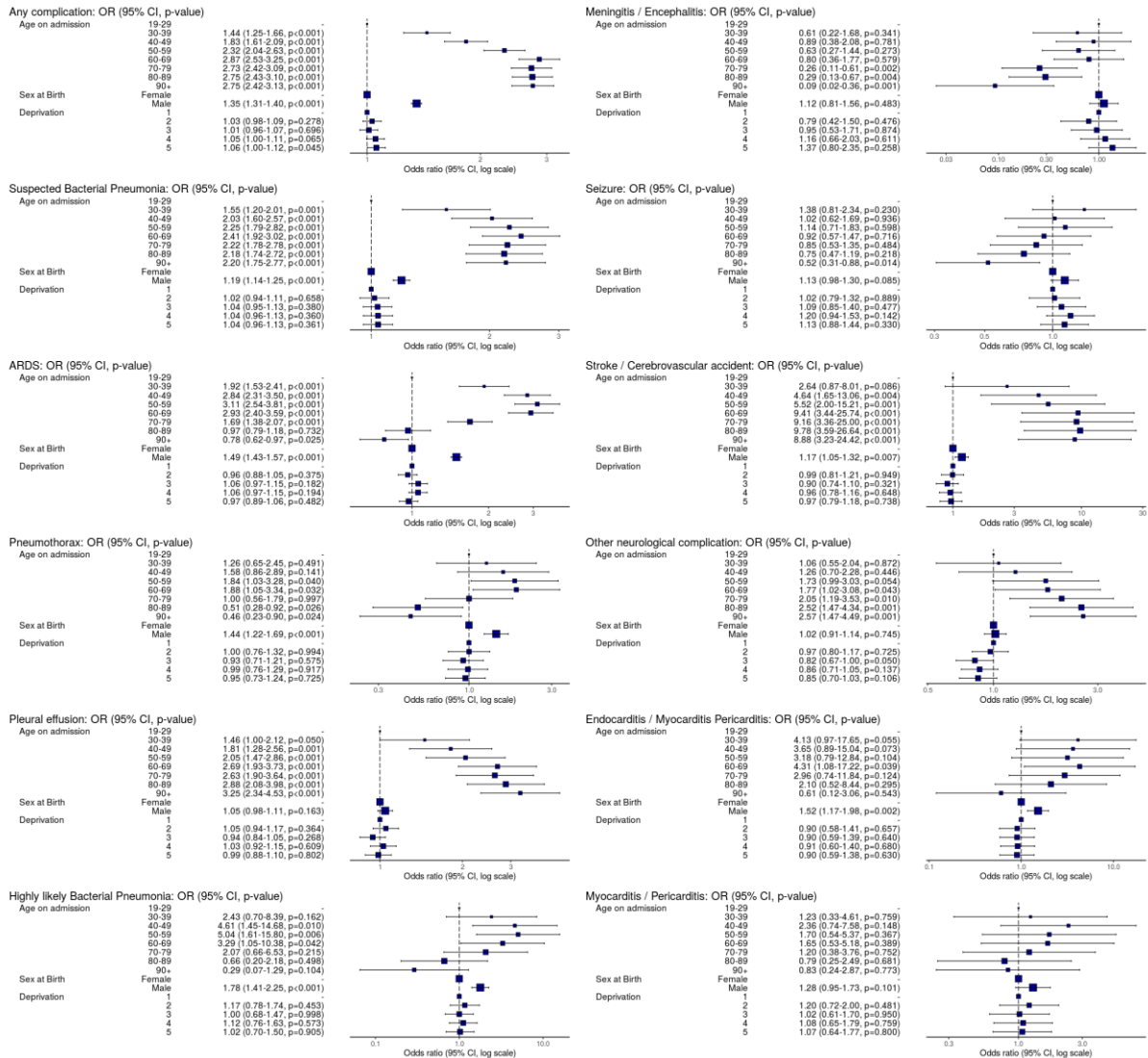
Dependent: Worse self- care ability		Equivalent to admission	Worse	OR (univariable)	OR (multilevel)
Respiratory complication	No	26708 (84.5)	4883 (15.5)	-	-
	Yes	3367 (68.0)	1582 (32.0)	2.57 (2.40- 2.75, p<0.001)	3.14 (2.91- 3.39, p<0.001)
Age on admission	19-29	1121 (95.4)	54 (4.6)	-	-
	30-39	1962 (91.6)	179 (8.4)	1.89 (1.39- 2.61, p<0.001)	1.75 (1.27- 2.43, p=0.001)
	40-49	3331 (89.0)	411 (11.0)	2.56 (1.93- 3.46, p<0.001)	2.21 (1.63- 3.00, p<0.001)
	50-59	5508 (87.6)	783 (12.4)	2.95 (2.25- 3.96, p<0.001)	2.60 (1.94- 3.50, p<0.001)
	60-69	5451 (84.4)	1010 (15.6)	3.85 (2.93- 5.15, p<0.001)	3.53 (2.63- 4.73, p<0.001)
	70-79	6239 (79.1)	1649 (20.9)	5.49 (4.20- 7.33, p<0.001)	5.45 (4.08- 7.29, p<0.001)
	80-89	6069 (76.0)	1920 (24.0)	6.57 (5.03- 8.77, p<0.001)	6.76 (5.06- 9.04, p<0.001)
	90+	1941 (73.6)	697 (26.4)	7.45 (5.65- 10.03, p<0.001)	7.78 (5.77- 10.50, p<0.001)
Sex at Birth	Female	14445 (82.6)	3047 (17.4)	-	-
	Male	17095 (82.4)	3639 (17.6)	1.01 (0.96- 1.06, p=0.736)	1.03 (0.97- 1.09, p=0.380)
Deprivation	1	4457 (81.7)	995 (18.3)	-	-
	2	5450 (81.3)	1254 (18.7)	1.03 (0.94- 1.13, p=0.520)	1.00 (0.90- 1.11, p=0.971)
	3	6708 (81.9)	1485 (18.1)	0.99 (0.91- 1.08, p=0.853)	1.04 (0.94- 1.15, p=0.498)
	4	6907 (82.2)	1494 (17.8)	0.97 (0.89- 1.06, p=0.485)	1.06 (0.96- 1.17, p=0.277)
	5	8090 (84.6)	1475 (15.4)	0.82 (0.75- 0.89, p<0.001)	0.95 (0.86- 1.06, p=0.378)

Supplementary Figures

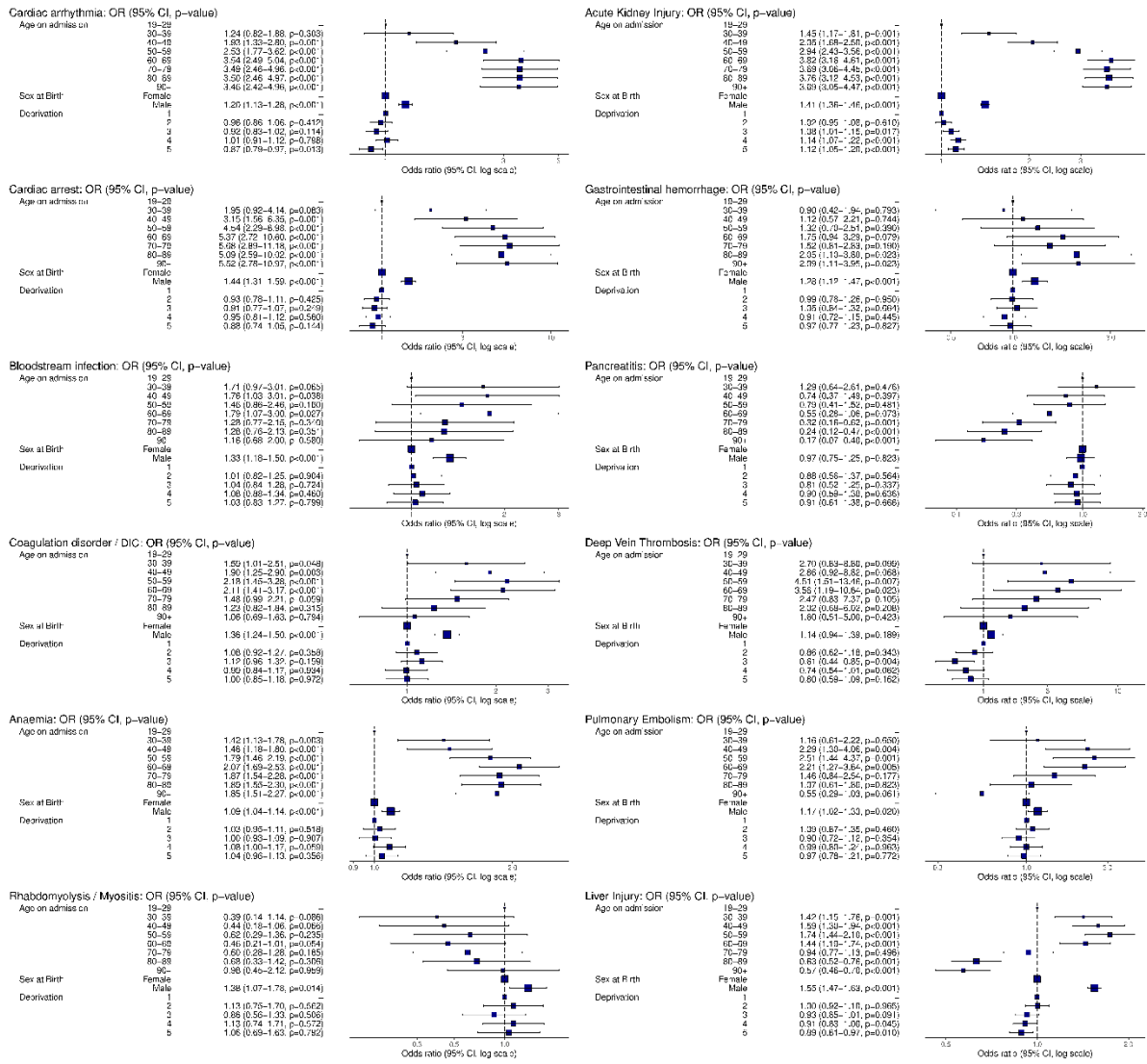
Supplementary figure 1 - Adjusted effect of age and sex on organ specific complications in adults with severe COVID-19 (also adjusted for centre as a random effect).



Supplementary figure 2 - Effect of age, sex and deprivation on specific complications in adults with COVID-19 (also adjusted for centre as a random effect).

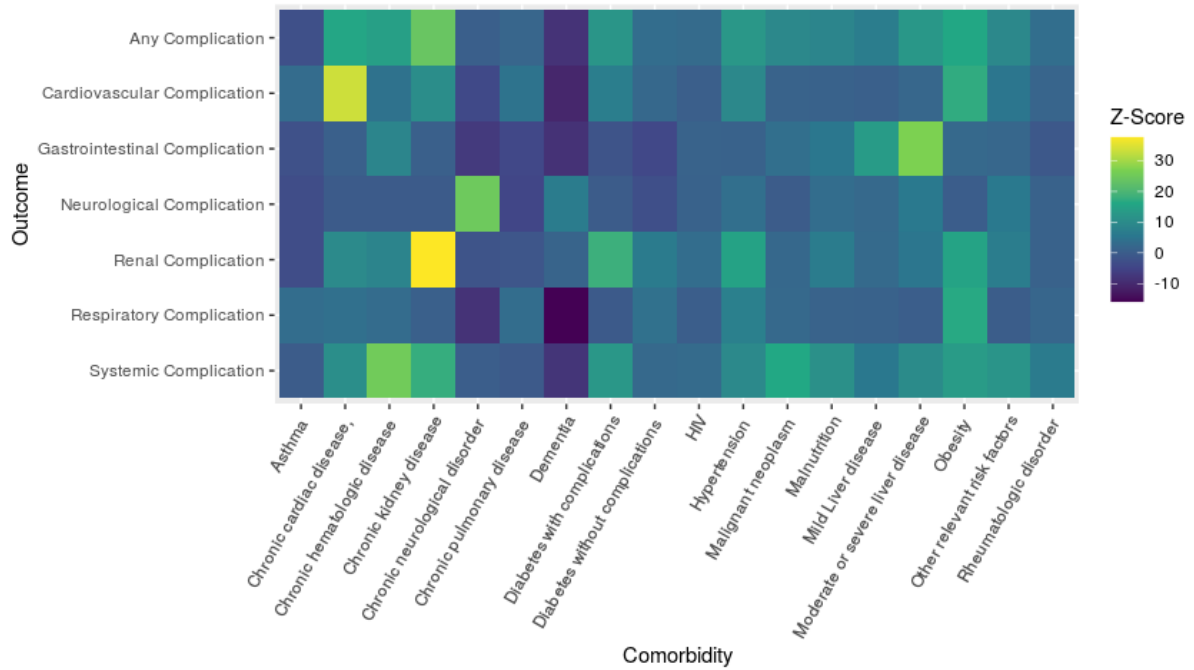


Supplementary figure 2 (continued) - Effect of age, sex and deprivation on specific complications in adults with COVID-19 (also adjusted for centre as a random effect).



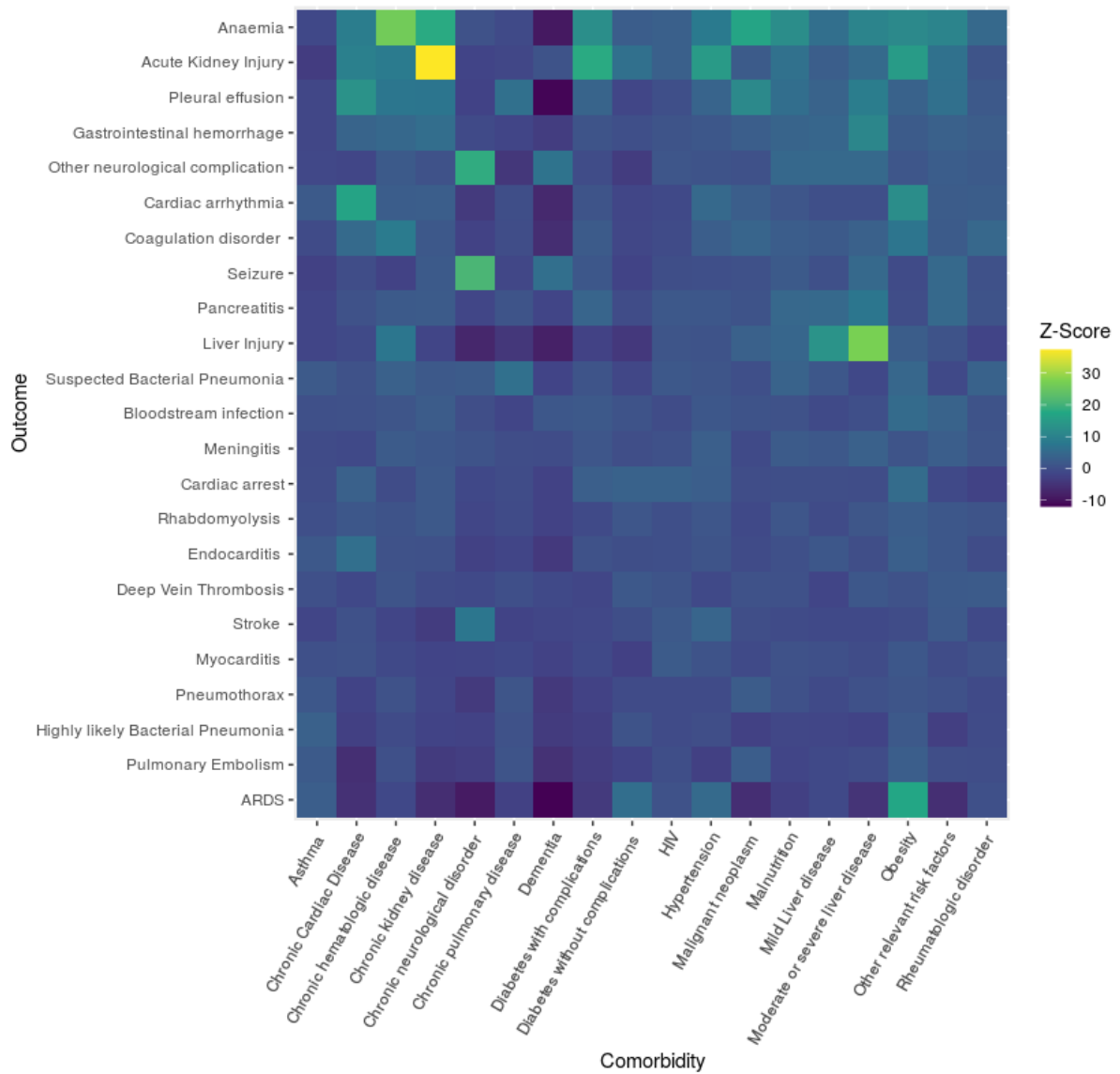
DIC- Disseminated intravascular coagulation.

Supplementary figure 3 - Associations between specific comorbidities and organ specific complications in adults with severe COVID-19.



A positive Z-score represents stronger associations between variables in positive direction, whereas negative z-score represents effect in opposite direction.

Supplementary figure 4 - Effect of specific comorbidities on specific complications in adults with COVID-19.



A positive Z-score represents stronger associations between variables in positive direction, whereas negative z-score represents effect in opposite direction.