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Quantifying excess mortality among non COVID-19 patients in healthcare settings

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Abstract

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Quantifying excess mortality among non COVID-19 patients in healthcare settings

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COVID-19 drastically increased demand- and supply pressures faced by healthcare systems. Increased pressures may have negative spillovers into non COVID-19 care which can cause preventable excess deaths among patients seeking medical help for reasons unrelated to COVID-19. This paper finds substantial and robust evidence of such non COVID-19 excess deaths among hospital patients leveraging data from an integrated public healthcare system: the NHS in England. We find that there is at least one additional preventable death among hospital patients seeking medical help for reasons unrelated to COVID-19 for every 30 deaths that can be linked to COVID-19. In aggregate, there were 4,003 such excess deaths during the first twelve months of the pandemic. At the healthcare provider level, the increase in non COVID-19 excess deaths is sharply increasing in COVID-19 induced pressures on hospitals.

Keywords: COVID-19; externalities; excess mortality; public health; pandemic; congestion effects

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1. Introduction

Health-care systems around the world are under continuous stress from rising infections and reinfections due to new COVID-19 variants and relaxed public health measures following the widespread availability of vaccinations (Mahase 2021; de Oliveira Andrade 2020). Intensive-care units (ICU) and health-care workers continue to be forced to work at and above capacity (Mehta et al. 2021) raising concerns about patient safety (Mira et al., 2020). Further, since COVID-19 patients occupy equipment beyond ICU beds, such as computed tomography scanners, naturally this may restrict access to other patients. The added stress and the diversion of resources to care for COVID-19 patients may have indirect effects on hospital patients that need help for reasons unrelated to COVID-19. This may lead to worse health outcomes and potentially cause excess deaths among those non-COVID-19 patients that counterfactually, without the COVID-19 disruptions, would not have occurred. Can we quantify such non COVID-19 excess deaths in healthcare settings? Are COVID-19 pressures on hospitals a causal driver of such non COVID-19 excess deaths?

It goes without saying that answers to these questions are vital as policymakers weigh the costs- and benefits of non-pharmaceutical interventions (Abaluck et al. 2021; Mitze et al. 2020; Fetzer and Graeber 2021), vaccination mandates and the resourcing of healthcare systems more generally (Kruk and Pate 2020). This paper is the first to develop a robust estimate of excess deaths among non COVID-19 patients arising from COVID-19's indirect impact on the healthcare system.[1] We find that, a robust method to quantify excess deaths among patients seeking medical help for reasons unrelated to COVID-19 and document that the prime driver of such excess deaths is COVID-19 induced pressures on healthcare providers. Yet, not surprisingly, such evidence was missing so far for three main reasons. First, studying health outcomes among patients that are in hospital for reasons unrelated to COVID-19 requires good surveillance of COVID-19 in hospital settings. Otherwise, there is always a concern that any excess death among patients may still be attributable to an undetected infection. Secondly, it requires data from an integrated healthcare system as patients could

[1] In Fetzer and Rauh (2022) we made preliminary findings of this study on the deterioation of health care and the increase and excess deaths available as preprints.

be accessing both COVID and non-COVID healthcare through numerous points of access. Most importantly, in order to measure excess deaths among non COVID-19 patients, we need to have a credible way of modelling and projecting forward mortality risks among hospital patients *under normal operating circumstances*.

The National Health Service (NHS) in England provides us with a context that navigates all of these challenges. Leveraging data from the population of hospital episodes within the NHS system linked to individual-level mortality data and COVID-19 testing data, the NHS can distinguish between patients that had a COVID-19 diagnosis code attached to their hospital episode. Since right from the start of the pandemic, all hospital patients were routinely screened for COVID-19 at admission and during their stay, this implies that virtually the universe of COVID-19 patients can be excluded enabling us to focus on non COVID-19 patients. Further, all deaths that mention a detected or suspected COVID-19 infection as cause or contributing factor in some form on the death certificate – the most comprehensive measure of COVID-19 linked deaths in the UK – are also excluded, further refining the focus on deaths among patients that sought medical help for reasons unrelated to COVID-19.

Most crucially, the NHS has built a statistical modelling tool allowing the estimation of expected mortality risk of an individual patient. Underlying the expected mortality is an individual patient level mortality risk estimate that is obtained from a model trained on *historic* individual-level NHS data leveraging a broad range of patient characteristics to predict the probability of death for each admitted patient within 30 days of admission. Since the statistical model is trained off historic data from prior to the pandemic, the underlying model captures the expected mortality risk of a hospital patient based on their characteristics and medical diagnosis assuming pre-pandemic *normal operating circumstances* of hospitals. We can use the output to construct a measure of the difference between the actually observed deaths and the expected number of deaths. Importantly, as indicated, we are able to fully focus on hospital episodes among individuals who have not had a COVID-19 diagnosis and who did not have COVID-19 mentioned on their death certificate, enabling us to focus fully on patients that were seeking medical help for reasons unrelated to COVID-19.

Figure 1 presents a view of the overall time-series patterns in the non-COVID-19 excess

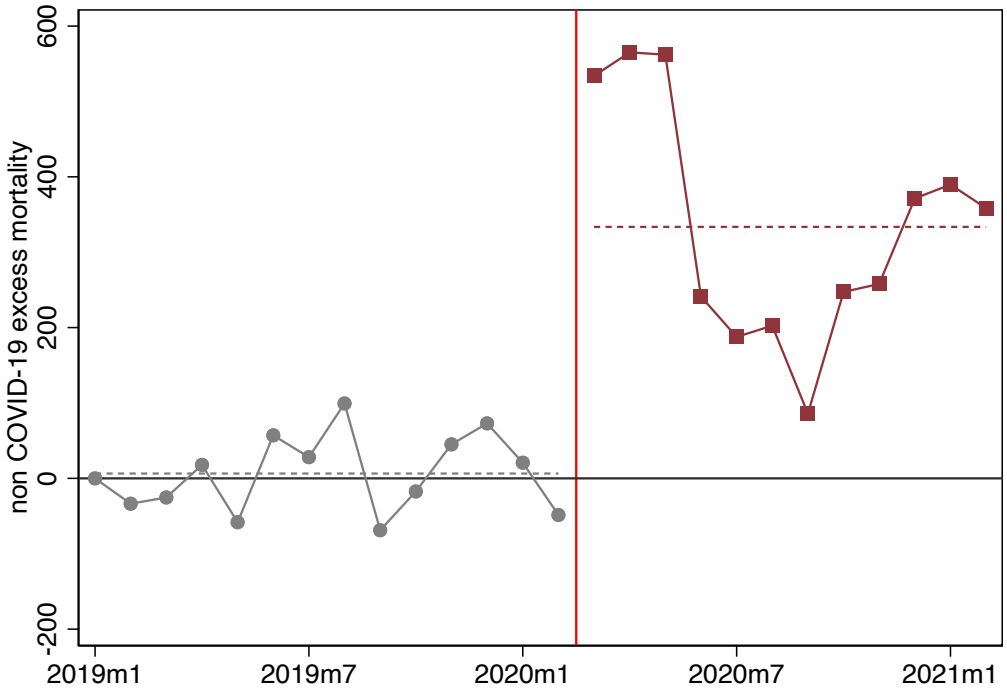
deaths in healthcare settings. The points capture the evolution of the estimated excess deaths up until February 2021 across NHS providers. On average prior to the pandemic, the resulting measure of excess mortality is centered around zero suggesting that the individual level mortality risk model has good out-of-sample predictive power (see also Figure B.2). With the arrival of the virus in England in March 2020 the red squares jump upwards sharply with almost 600 excess deaths among patients in hospital for reasons unrelated to COVID-19 during each of the first three months. In the following months there continue to appear systematic deviations in the excess death measure with observed deaths being significantly larger than expected deaths among non COVID-19 patients. This suggests that the individual-level patient mortality risk estimate trained off historic data may produce expected mortality risk measures that are downward biased due to a significant omitted variable: the impact of the pandemic on the quality of care non COVID-19 patients receive.

We estimate that, for the first twelve months of the pandemic from March 2020 to February 2021 alone, there have been at least 4,003 excess deaths of hospital patients in England that, if it were not for the pandemic disruptions, would not have died. This number stands significant in the context of actual and estimated COVID-19 deaths. In the same period, the most comprehensive measure of COVID-19 deaths for England counted 127,475 that mention COVID-19 on the death certificate (see also Table B.1 and Figure B.1) .

Our estimates suggest that the excess deaths among hospitals episodes of around 4,003 individual cases between March 2020 and February 2021 stand at a non-negligible 3.9% of all excess deaths or 3.1% of all deaths mentioning COVID-19 on the death certificate that were captured during that period.

We also find that the number of non-COVID-19 excess deaths rises sharply with the number of hospitalized COVID-19 patients. For every doubling of COVID-19 patients, there is an additional three to four non COVID-19 excess deaths. Moreover, non COVID-19 excess mortality tend to exhibit a stronger relationship with hospitalized COVID-19 patients in areas with a greater catchment population, a higher share of minorities, a lower share of old people, and less deprivation. This suggests that the indirect health burden of COVID-19 care may have been born by younger- and minority populations in relatively less deprived areas

Figure 1. : Estimates of excess mortality across English healthcare providers over time.



Notes: The figure plots the difference between the expected- and the observed number of deaths within 30 days among patients that visit an English NHS hospital. The number excludes all individuals who either tested positive for COVID-19 or whose death certificate mentions COVID-19 thereby focusing on non-COVID-19 excess mortality. The *expected* number of deaths is computed based on a statistical model of patient level characteristics at the point of hospital admissions using a statistical model trained on data from prior in the pandemic. The gray dots represent the pre-pandemic months and the red squares the months during the pandemic. The red dashed line represents the mean of the pandemic months.

receiving worse care. This result may seem surprising but could reflect the fact that, prior to the pandemic, areas that structurally had higher levels of demand for healthcare (due to having an older, less healthy population) also had, on the margin, higher levels of resources devoted to them (Barr et al. 2014), potentially enabling them to cope better with COVID-19 disruptions. We next describe these analysis in more detail.

2. Data and measurement

Measuring non COVID-19 excess mortality

The Summary Hospital-level Mortality Indicator (SHMI) reports on mortality at the NHS trust level across England and is produced as an official monthly statistic by NHS Digital. The SHMI includes deaths which occurred in hospital or within 30 days of discharge and is calculated using Hospital Episode Statistics (HES) data linked to Office for National Statistics (ONS) death registrations data.[2] The SHMI is the ratio between the actual number of patients who die following hospitalisation at the trust level and the number that would be expected to die. The expected probability of an individual patients death is estimated from a statistical model based on the characteristics of the patients. These characteristics include the condition the patient is in hospital for, other underlying conditions the patient suffers from, age, gender, method and month of admission to hospital, and birthweight (for perinatal diagnosis groups). For each admission a risk of death score is computed for which then the cumulative expected deaths can be computed and contrasted with the observed number of deaths that occur while patients were in hospital or within 30 days of discharge. Crucially, the SHMI data remove any activity or death that is related to COVID-19. Specifically, if any hospital episode within a provider spell have a COVID-19 diagnosis code recorded (such as, for example, if a patient tests positively for COVID-19), then the spell is excluded from the analysis. Since all admitted patients are routinely tested for COVID-19 this implies that virtually all hospital episodes under consideration exclude COVID-19 patients. Moreover, for all deaths included in the SHMI, if COVID-19 is recorded anywhere on the death certificate, then the death and the

[2]This data is available at `https://digital.nhs.uk/data-and-information/publications/statistical/shmi/`.

spell it is linked to are also excluded from the SHMI. This ensures that we focus exclusively on deaths and in particular, excess deaths in care settings that are not directly attributable to COVID-19, but may still be driven by COVID-19, due to its impact on the quality of care that can be provided.

Figure 2 highlights that the exclusion of COVID-19 cases from the SHMI data at the provider level is very tightly correlated with the number of COVID-19 cases in the catchment areas of NHS providers (panel A) and with the number of patients admitted to hospital with a COVID-19 diagnosis (panel B). This highlights that our underlying data capturing hospital episodes of non COVID-19 patients is likely doing very well at removing COVID-19 patients from it implying that the excess deaths estimates are likely very accurate.

The excess deaths data is reported as twelve month rolling cumulative totals, that is, for example, the monthly publication of March 2020 includes the cumulative total number of hospital episodes or "spells", the number of observed deaths or the number of expected deaths over the twelve month window ranging from April 2019 to March 2020 inclusive. That is, for every reporting month t, the measures we capture the twelve month cumulative totals, that is, $\sum_{\tau=t-12}^{t} \text{Obs}_{p,\tau}$, $\sum_{\tau=t-12}^{t} \text{Exp}_{p,\tau}$ and $\sum_{\tau=t-12}^{t} \text{Spells}_{p,\tau}$.

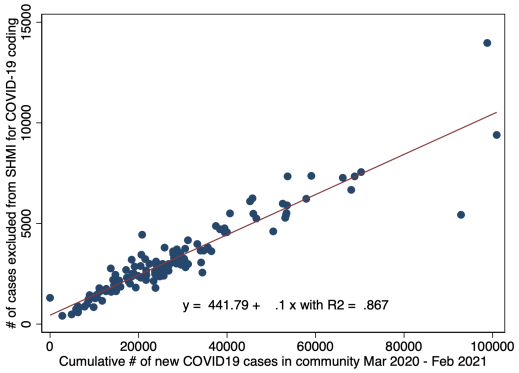
We can compute the number of excess deaths in a twelve month rolling window as reported in month t as

$$\sum_{\tau=t-12}^{t} \text{Excess}_{p,\tau} = \sum_{\tau=t-12}^{t} \text{Obs}_{p,\tau} - \sum_{\tau=t-12}^{t} \text{Exp}_{p,\tau}.$$

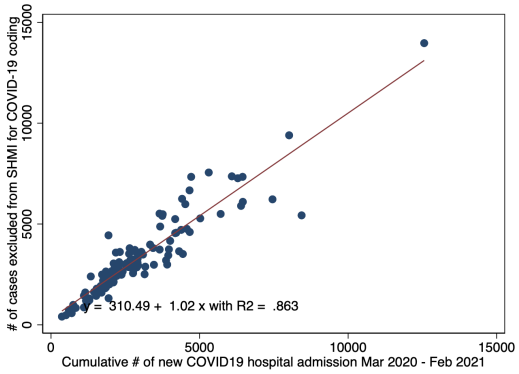
Naturally, the above measure can be considered to be the residual of a regression that is the result of having aggregated the individual predicted mortality risks $h(x_{i,p,t})$ of observation i that is captured in a set of features x about the individual i. If this model was unbiased, we would expect that the expected value of this measure $E(\sum_{\tau=t-12}^{t} \text{Excess}_{p,\tau} | h(x)) = 0$. Naturally, if there was an omitted variable $z_{i,p,t}$ either at the individual, provider- or time level that affects the number of observed deaths in a way that the statistical model to generate the expected deaths measure has not taken into account for – i.e. if there is an *omitted variable* - in the risk model, we would expect the above condition to be violated, i.e. that there is

Figure 2. : Comparison of COVID-19 cases in community and admitted to hospital and COVID-19 case data being removed from the SHMI data product

Panel A: Community COVID-19 Cases



Panel B: Cumulative COVID-19 hospital admissions



Notes: Figure shows the relationship between COVID-19 cases in the community or catchment areas of NHS providers (panel A) or COVID-19 hospital admissions (panel B) and the number of COVID-19 hospital episodes that have been removed from the SHMI mortality modelling. The figure suggests a tight fit with a near one-to-one relationship between individuals admitted to hospital with a COVID-19 infection (panel B) and the number of hospital spells excluded for the estimation of non COVID-19 excess mortality. This suggests that the SHMI product is cleaned and fully focusing on patients that seek medical help for reasons unrelated to COVID-19.

indeed some structure in the residuals. We document that up to February 2020, there is no structure in the residuals with the average excess deaths across providers and over time to hover close to zero. Yet, from March 2020 onwards, the pattern suggests that there is indeed an important omitted variable in the risk model that results in a notable divergence between the observed number of deaths and the expected number of deaths.

Measuring provider-level exposure to COVID-19

We construct three measures to capture providers' exposure to COVID-19 pressure observed directly at the health care provider level: (i) the number of new hospital admissions who tested positive for COVID-19 in the 14 days prior to hospital admissions or who during their stay in hospital inpatients were diagnosed with COVID-19 after admission, (ii) the number of cases in hospital measured as the number of people currently in hospital with confirmed COVID-19 through a positive PCR test for COVID-19 in the past 14 days, and (iii) the number of COVID-19 patients in beds which can deliver mechanical ventilation. The data is available at `https://www.england.nhs.uk/statistics/statistical-work-areas/covid-19-hospital-activity/`.

3. Empirical strategy

In order to compute excess deaths, we rely on a a statistical model used by the NHS leveraging historic individual level patient data $x_{i,p,t}$ measured at the individual hospital episode i, across healthcare providers p at time t. This data is linked to official mortality registers capturing whether a patient i died within 30 days of admission. Let $y_{i,p,t}$ indicate the outcome taking the values:

$$y_{i,p,t} = \begin{cases} 1 & \text{if patient died} \\ 0 & \text{patient survived.} \end{cases}$$

The model predicts $P(y_{i,p,t} = 1|x_{i,t})$, the probability of death within 30 days given individual patient characteristics. These characteristics, among others, include features such as

the mode of hospital admission, admissions weekday and hour-of-day, age, gender, health conditions and various diagnosis codes. These predicted probabilities are then transformed at the provider and month level to compute the expected number of deaths. Importantly, the model that is trained using historic data to predict mortality outcomes at the hospital episode level does not include any variables measuring provider-level characteristics. This is intentional as the data was originally developed for performance monitoring whereby hospitals are flagged up if they perform notably worse in providing care preventing deaths relative to the pool of NHS providers as a whole. We measure, for each provider p, the actually observed deaths within 30 days among hospital episodes linked to that provider $Y_{p,t} = \sum_i y_{i,p,t}$ in a given month t along with the expected numbers of deaths from the predictive model $\hat{Y}_{p,t} = \sum_{i=1}^{n} P(y_{i,p,t} = 1|x_{i,t})$. This allows us to compute a measure of excess deaths as

$$\hat{\xi}_{p,t} = \hat{Y}_{p,t} - Y_{p,t}$$

which constitute our measure of excess deaths at the provider level p in month t.

Figure 1 previously showed how the overall pattern suggests that the residual aggregated at the monthly level jumped sharply with the onset of the pandemic and remained consistently elevated. Next we explore whether additional features $x_{p,t}$ that vary *at the provider level* p over time t – not measured at the hospital episode level i – can account for systematic deviations in this excess deaths. Specifically, we regress the measure of non COVID-19 excess mortality $\hat{\epsilon}_{p,t}$ on provider-time specific pressures COVID-19$_{p,t}$, provider level fixed effects α_p, month fixed effects ν_t, the number of hospital episodes in the current month and the excess deaths one year ago at the provider level $x_{p,t}$ using the following form:

$$\hat{\xi}_{p,t} = \alpha_p + \nu_t + \beta \times \text{COVID-19}_{p,t} + \gamma \times x_{p,t} + \epsilon,$$

while clustering standard errors at the provider level. The coefficient of interest, β, captures the impact of COVID-19 pressures on excess deaths.

We test three provider-time specific COVID-19$_{p,t}$ pressures directly at the healthcare provider level: the log of the number of (i) new hospital admissions who tested positive for COVID-19

in the 14 days prior to hospital admissions or who during their stay in hospital inpatients were diagnosed with COVID-19 after admission, (ii) patients currently in hospital with confirmed COVID-19 through a positive PCR test for COVID-19 in the past 14 days, and (iii) COVID-19 patients in beds which can deliver mechanical ventilation.

We additionally investigate whether the transmission of COVID-19 pressures depends on certain characteristics c_p of the resident population that is served by a provider p using the same specification as above, while adding an interaction term between c_p and COVID-19$_{p,t}$ pressures. The characteristics c we look at are the deprivation score of the population served by a provider, the share of minority Black or Asian among the population, the log of total population, and the share of people below age 65 in the catchment area of provider p. These characteristics of the catchment area are measured in 2019 and are features that commonly surface in the discussion of (unequal) health care and outcomes.

Finally, we also conduct some heterogeneity analysis in terms of excess mortality for different diagnosis. That is, we study which types of non-COVID-19 diagnosis are more likely to result in non-COVID-19 excess deaths. To do so, we compute whether for a specific diagnosis d, our excess-deaths measure

$$\hat{\xi}_{p,t,d} = \hat{Y}_{p,t,d} - Y_{p,t,d}$$

varies systematically depending on the pressures COVID-19$_{p,t}$ experienced at the provider level p over time t. This data is much more sparse and subject to statistical data disclosure control. Given the granularity of the diagnosis codes, 145 in total, we limit our analysis to the 15 most common ones for which we have consistent non-suppressed data across at least 100 of the 124 main NHS providers.

4. Results

The results from our main analysis are presented in Figure 3 (see also Appendix Tables B.2-B.3). The dependent variable measures the month on month change in the number of excess deaths. The point estimates from the three separate regressions suggest that a 10% increase in the total number of hospitalized COVID-19 cases translates into 0.26 additional excess deaths, the number of average daily new hospital admissions due to COVID-19 translates into 0.43

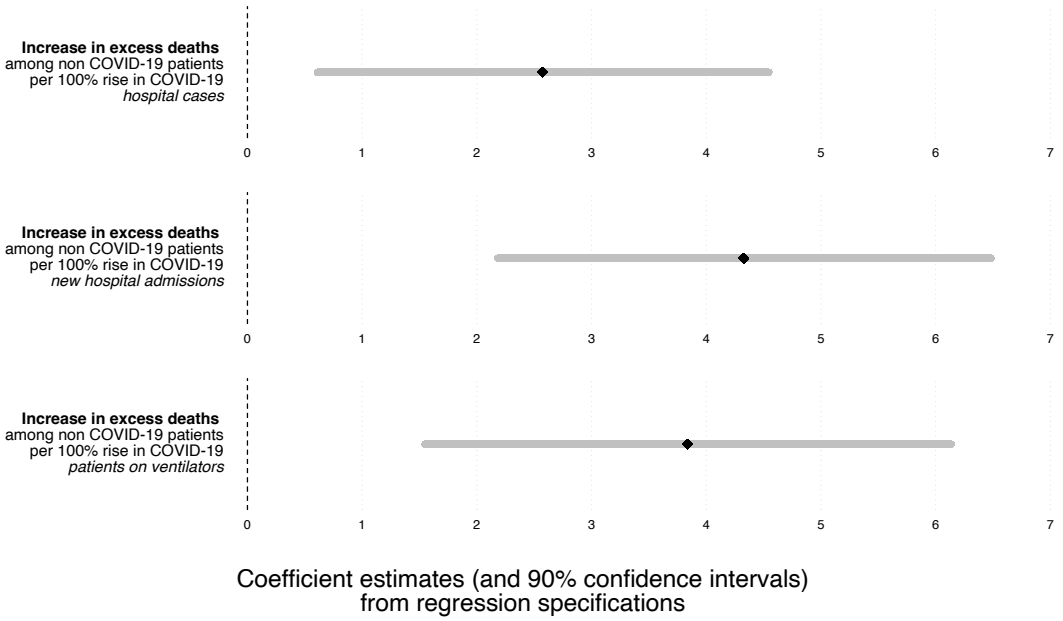
additional excess deaths, and the number of COVID-19 patients on ventilators translates into 0.38 additional excess deaths. Most result remains robust across different specifications, including, adding linear-time trends and community infection rates at the provider level.

We find that, in particular, pressures from increases in new COVID-19 hospital admissions and occupation of beds with mechanical ventilation is associated with significant worsening survival chances for patients that get admitted to hospital for non COVID-19 reasons. Appendix Figure B.3 indicates that the effects are strongest in hospitals that experience, based on its empirical distribution, relatively large shocks of new COVID-19 patients being admitted. Further, Appendix Tables B.4-B.6 find very similar results when adapting the empirical design to study the excess mortality data as reported by NHS digital as twelve months rolling cumulative totals, for which, we then construct a rolling cumulative measure of the COVID-19 pressures to match that data structure.

In Figure 4 we present the systematic heterogeneity in terms of the transmission of the COVID-19 pressures through cases of COVID-19 patients depending catchment area characteristics of the provider. The plotted interaction terms indicate that hospitalized COVID-19 patients lead to more deaths if the catchment area of the provider in 2019 featured a greater total population, more Black or Asian minorities, greater share of younger people, and is lower in areas with greater deprivation. In Appendix Figures B.4-B.5 we show that the patterns are similar for the transmission of COVID-19 pressures related to the number of newly admitted COVID-19 patients and those on ventilators.

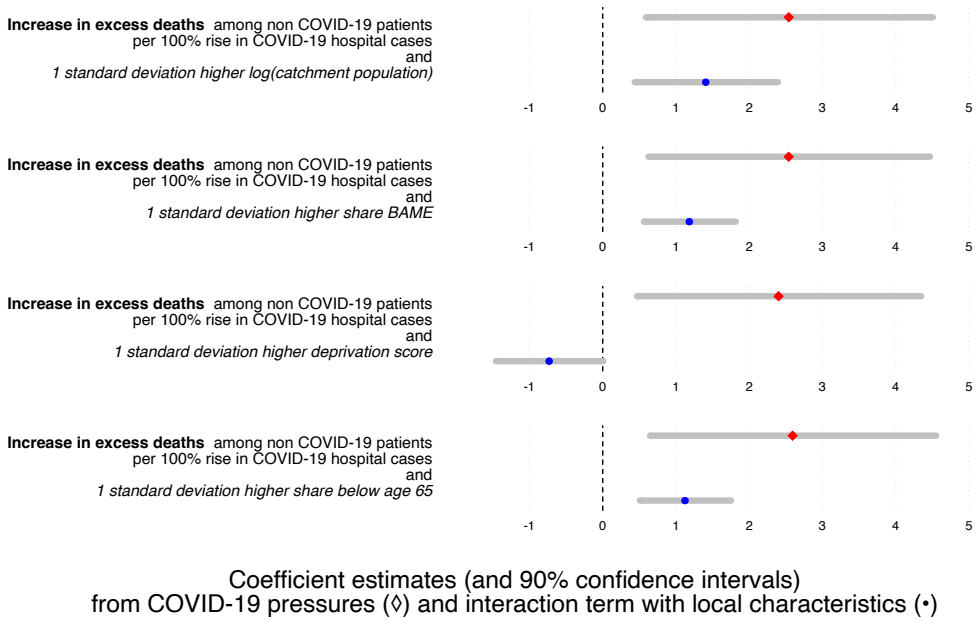
Finally, Figure 5 presents results from estimating the heterogenous effects focusing on 15 of the 142 diagnosis codes. The increase in mortality at the provider level is driven, to a significant extent, by urgent care needs, such as heart attacks (acute myocardial infraction) or gastrointestinal hemorrhage. This suggests that COVID-19 induced hospital pressures are causing a notable increase in non COVID-19 related excess deaths due to, likely, a worse quality and speed of care.

Figure 3. : Impact of COVID-19 pressures across NHS healthcare providers on non COVID-19 excess mortality.



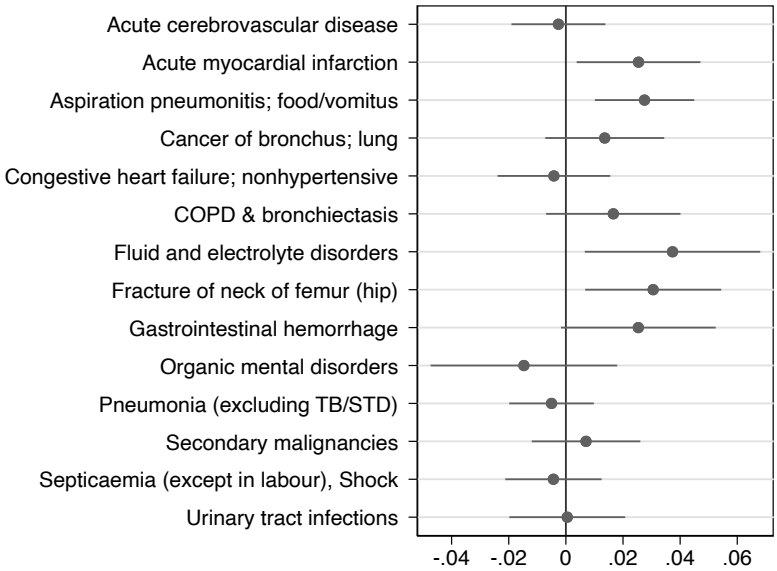
Notes: The figure plots coefficients from regression estimates at the NHS provider level. The point estimate captures the effect of a 100% change in COVID-19 pressures on the number of excess deaths in a given month among patients seeking medical help for reasons unrelated to COVID-19. Across the rows we measure COVID-19 pressures either as number of cases in hospital, the monthly average new daily COVID-19 hospital admissions, or the average number of cases on mechanical ventilation in a given month. All regressions control for NHS provider fixed effects and time fixed effects. Complete regression results are reported in Table B.2. 90% confidence intervals obtained from clustering standard errors at the provider level are indicated.

Figure 4. : Impact on non COVID-19 excess mortality of the number of hospitalized COVID-19 patients depending on characteristics of the catchment area of NHS healthcare providers.



Notes: The figure plots the coefficients of the number of hospitalized COVID-19 patients (red diamond) and of the interaction term with catchment area characteristics (blue dot) from regression estimates at the NHS provider level. The interaction term captures the effect of a 100% change in COVID-19 pressures combined with a one standard deviation increase in the catchment area characteristic on the number of excess deaths in a given month among patients seeking medical help for reasons unrelated to COVID-19. We measure COVID-19 pressures as the number of hospitalized COVID-19 patients in a given month. The catchment area characteristics are the deprivation score, the share of Black or Asian, the log of total population, and the share of people below age 65 in the catchment area of the provider. All regressions control for NHS provider fixed effects and time fixed effects.

Figure 5. : Impact of COVID-19 pressures on diagnosis specific excess mortality.



Notes: The figure presents heterogenous treatment effects capturing the impact of COVID-19 pressures on diagnosis specific excess mortality. The estimating equation explores variation in the log differences in observed minus expected deaths for hospital episodes and diagnosis for which data is available for the whole sample period and for diagnosis that are consistently included in the data across at least 100 of the 127 NHS providers for which the data is constructed. All regressions control for provider by diagnosis fixed effects as well as diagnosis by time fixed effects and control for the diagnosis-specific relationship between log(spells) and excess deaths. 90% confidence intervals obtained from clustering standard errors at the provider level are indicated.

5. Discussion

This paper provides a first estimate decomposing excess deaths arising from COVID-19 indirectly due to its impact disrupting health care demand- and supply. We show that the spillover effects on patients admitted to hospital for non COVID-19 related health issues is of first order. For every 25 to 32 deaths that are directly linked to COVID-19 during the first year of the pandemic, there is at least one excess death among hospital patients seeking medical help for reasons unrelated to COVID-19. The excess deaths among non COVID-19 patients is strongly increasing in COVID-19 healthcare pressures. We note that these measures of excess deaths are likely to be lower bounds as they focus on excess deaths among hospital patients. Yet, it is likely that in the coming years there will be further excess deaths arising from delayed care or detection of cancer or other diseases (Lai et al. 2020a; Maringe et al. 2020; Fetzer and Rauh 2022).

Most existing studies have solely focused on estimating overall excess deaths, often simply because of there being a lack of data on COVID-19 deaths. For example, for India (Adam 2022; Jha et al. 2022) and the US (Ruhm 2021) it was estimated by numerous studies that the true number of COVID-19 deaths may be actually notably larger, and for the US non COVID-19 mortality increased in particular amongst Black men (Cronin and Evans 2021). This paper actually quantify excess deaths amongst patients seeking healthcare for reasons unrelated to COVID-19. We document that COVID-19 pressures are a significant driver of excess deaths among non COVID-19 patients. We are able to provide a lower bound on the likely number of deaths that may have been caused by the deterioration of care that patients receive in hospital under COVID-19 stress. Our approach contrasts with existing work looking at excess deaths relying on modelling studies of the likely increases, e.g. due to undetected or delayed treatment of cardiovascular diseases (Banerjee et al. 2021), cancer (Lai et al. 2020b), or lacking access to insurance (Galvani et al. 2022).

As the world is moving to an equilibrium to live with the COVID-19 virus, it remains important to derive lessons learned from the pandemic not only for future pandemics, but also for the continuing pressures that arise. Healthcare systems were already facing chronic issues coming into the pandemic. Our findings raise the question of how to deal with large scale

infectious outbreaks in order to limit spillover effects. Our estimates are likely to constitute a lower bound given that many patients avoided visiting hospitals due to fear of becoming infected and thereby alleviated some congestion. We cannot answer the question whether healthcare providers should specialize the provision of care in order to be able to isolate usual care from the care for a pandemic, or whether healthcare systems require more generous buffers in terms of staffing and facilities in order to accommodate large shocks. Our robust findings, however, suggest that the large spillover effects are systematic and require more attention.

Data Availability

Previously published data were used for this work with various sources of publicly available COVID-19 data as specified in the text and Appendix. All data and code will be made available upon publication.

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Appendix A: Data and Methods

Measuring provider-level exposure to COVID-19

NHS trusts are not defined spatially explicitly, but rather, can serve multiple regions. Yet, most NHS Trusts are spatially quite concentrated. To allocate NHS trusts and providers to specific locations and to merge in additional data, we leverage an analysis of individual-level micro data from the Hospital Episodes Statistics dataset which breaks down all hospital visits to an NHS provider location by the location of residence of the patients at the granular middle layer super output area (MSOA) which have, on average, a population of 8,000 residents.We allocate MSOA's to NHS trusts on the basis of a first-past-the-post basis – that is, an MSOA is counted towards the catchment area of an NHS trust if that trust handles the most hospital episodes across all NHS trusts that serve residents from this MSOA. As illustrated in Appendix Figure A.1 there is, not surprisingly, ample spatial clustering implicit in this. Having this mapping of MSOA's that are spatially explicit to NHS trusts (which may operate out of several sites within an area) allows us to construct measures of the cumulative community exposure to COVID-19 as COVID-19 case figures are provided at the MSOA level.

Transforming SHMI data to uncover monthly structure

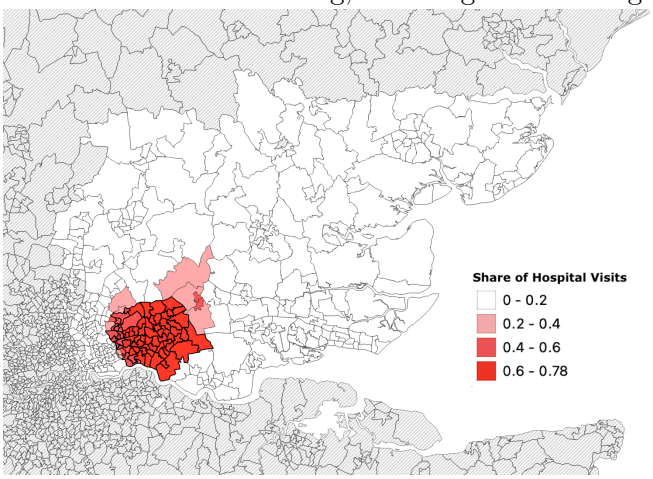
The Hospital Episode Statistics (HES) data linked to Office for National Statistics (ONS) death registrations data is available at `https://digital.nhs.uk/data-and-information/publications/statistical/shmi/`. The reported data in a given reporting month t provides the cumulative totals of the observed- and expected deaths $\sum_{\tau=t-12}^{t} \text{Obs}_{p,\tau}$ and $\sum_{\tau=t-12}^{t} \text{Exp}_{p,\tau}$. This implies we can compute the month-on-month changes as

$$\begin{aligned}\Delta\text{Excess}_{p,t} =&[\sum_{\tau=t-12}^{t} \text{Obs}_{p,\tau} - \sum_{\tau=t-12}^{t} \text{Exp}_{p,\tau}] - [\sum_{\tau=t-13}^{t-1} \text{Obs}_{p,\tau} - \sum_{\tau=t-13}^{t-1} \text{Exp}_{p,\tau}] \\ =&[\text{Obs}_{p,t} - \text{Exp}_{p,t}] - [\text{Obs}_{p,t-13} - \text{Exp}_{p,t-13}].\end{aligned} \tag{A1}$$

Figure A.1. : Allocation of spatial areas to NHS Trusts

Panel A: MSOA's across England

Panel B: Visits to Barking, Havering and Redbrige NHS Trust



Notes: Map displays the residential address of visitors to the Barking, Havering and Redbrige University Hospital NHS Trust in 2019. The left figure plots the distribution across England's 6791 MSOAs. The hospital trust saw hospital visits from patients coming from 412 MSOAs. The right figure provides a zoom in on the spatial distribution of patients visiting the Barking, Havering and Redbrige University Hospital NHS Trust in 2019 and what share of visits are made up by residents from different MSOAs. The vast majority 83% come from 70 MSOAs that are immediately in the neighborhood of the trusts's main hospitals: the King George Hospital and the Queen's Hospital. The solid dark lines in the right panel indicate the MSOAs that are attributed to the NHS Trust by virtue of the trust's hospitals have been serving most of the patients that had
a hospital spell in 2019 that reside in each MSOA. This data is available on `https://app.powerbi.com/view?r=eyJrIjoiODZmNGQ0YzItZDAwZiOOMzFiLWE4NzAtMzVmNTUwMThmMTVlIiwidCI6ImVlNGUxNDk5LTRhMzUtNGIyZS1hZDQ3LTVmM2NmOWRlODY2I`

This implies we can capture the number of excess deaths in a given month t, rather than the twelve month rolling window in the above expression. If we denote the genuine monthly excess number of deaths as $Excess_{p,t} = \text{Obs}_{p,t} - \text{Exp}_{p,t}$, we can exploit month-on-month variation in COVID-19 pressures at the hospital level by estimating variations of the below specification:

$$Excess_{p,t} = \alpha_i + \nu_p + \gamma_t + \beta \times \text{COVID-19}_{p,t} + \xi \times \mathbf{X}_{p,t} + \nu_{i,p,t}. \tag{A2}$$

Crucially, given the above transformation, the vector of additional control variables $\mathbf{X}_{p,t}$ should include $[\text{Obs}_{p,t-13} - \text{Exp}_{p,t-13}]$.

As indicated, the data from NHS Digital (2021) provide us with an estimate of the expected mortality of hospital admissions for each diagnostic based on a range of patient characteristics. Importantly, this excludes all COVID-19 related deaths. We study whether with the start of the pandemic, the structure of excess deaths is different compared to before the pandemic started, and further, to what extent month-on-month variation in COVID-19 pressures is affecting the excess deaths. As the data is reported at the monthly level but as twelve month cumulative rolling totals this dampens the month-on-month variation. We carry out two complementariy exercises that document however, that this is not an issue.[3] The reported data in a given reporting month t provides the cumulative totals of the observed- and expected deaths $\sum_{\tau=t-12}^{t} \text{Obs}_{p,\tau}$ and $\sum_{\tau=t-12}^{t} \text{Exp}_{p,\tau}$. This implies we can compute the month-on-month changes as

$$\begin{aligned} \Delta\text{Excess}_{p,t} =& [\sum_{\tau=t-12}^{t} \text{Obs}_{p,\tau} - \sum_{\tau=t-12}^{t} \text{Exp}_{p,\tau}] - [\sum_{\tau=t-13}^{t-1} \text{Obs}_{p,\tau} - \sum_{\tau=t-13}^{t-1} \text{Exp}_{p,\tau}] \\ =& [\text{Obs}_{p,t} - \text{Exp}_{p,t}] - [\text{Obs}_{p,t-13} - \text{Exp}_{p,t-13}]. \end{aligned} \tag{A3}$$

This implies we can capture the number of excess deaths in a given month t, rather than

[3] A monthly rather than twelve month rolling sum of the excess mortality data was requested by the researchers via email and via a Freedom of Information request – all communication relating to this FOI request can be tracked here `https://www.whatdotheyknow.com/request/shmi_data_by_provider_at_monthly`.

the twelve month rolling window in the above expression. If we denote the genuine monthly excess number of deaths as $Excess_{p,t} = \text{Obs}_{p,t} - \text{Exp}_{p,t}$, we can exploit month-on-month variation in COVID-19 pressures at the hospital level by estimating variations of the below specification:

$$Excess_{p,t} = \alpha_i + \nu_p + \gamma_t + \beta \times \text{COVID-19}_{p,t} + \xi \times \mathbf{X}_{p,t} + \nu_{i,p,t}. \tag{A4}$$

Crucially, given the above transformation, the vector of additional control variables $\mathbf{X}_{p,t}$ should include $[\text{Obs}_{p,t-13} - \text{Exp}_{p,t-13}]$ as control variable.

Alternatively, we also estimate alternative specifications that do not transform the data in the above fashion. Given the reporting in twelve month cumulative totals this implies we need to measure the COVID-19 pressures not month-on-month but similarly compute cumulative totals over a time window. For example, we can estimate the impact of COVID-19 pressures in the last ξ month relative to the reporting month t on the log difference in observed- vis-a-vis expected number deaths cumulatively in the last twelve months as in

$$\log \sum_{\tau=t-12}^{t} \text{Obs}_{p,\tau} - \log \sum_{\tau=t-12}^{t} \text{Exp}_{p,\tau} = \nu_p + \gamma_t + \beta \times \sum_{\tau=t-12}^{\xi} \text{COVID-19}_{p,\tau} + \nu_{p,t}.$$

Catchment area characteristics

The provider catchment characteristics are available at `https://digital.nhs.uk/`. We use the provider characteristics of the catchment areas for all admissions in 2019. All measures are standardized with mean zero and a standard deviation of one before interacted with the respective COVID-19 pressures. The English Indices of Deprivation 2019 are computed based on seven weighted domains of deprivation: income 22.5%, employment 22.5%, education 13.5%, health 13.5%, crime 9.3%, barriers to housing and services 9.3%, and living environment 9.3%. The information about the measure of deprivation is available at `https://www.gov.uk/government/statistics/english-indices-of-deprivation-2019`. A higher deprivation score is associated with greater deprivation.

Diagnostic-specific empirical design

For the diagnostic-specific analysis we follow the same procedure while splitting the sample by diagnosis code. The database features 142 diagnosis codes. Since we are analyzing provider-level data, the data becomes when split the sample for each of the diagnosis codes. Therefore, we limit our analysis to 15 of the 142 diagnosis codes which are consistently included in the data across at least 100 of the 127 NHS providers. Even when only focusing on the 15 most prevalent diagnosis codes, the diagnosis-specific data is too sparse to allow us to estimate the preferred specification exploiting month-on-month changes. Hence, we work with the cumulative twelve month rolling window design to study to what extent COVID-19 pressures in the last three months affect the cumulative twelve month rolling sum of excess death by diagnostic group.

Comparison of COVID-19 death measures and non COVID-19 excess deaths

The analysis in Figure 1 suggests that cumulatively there have been at least 4,003 excess deaths among patients that have sought medical help for reasons unrelated to COVID-19 from March 2020 to February 2021 inclusive.

A natural comparison that arises is how large do these quantities stand in comparison to deaths directly caused by COVID-19. This appendix section provides such a comparison. There are numerous methods used in the UK and across countries to measure the number of deaths that arise from COVID-19. There exist numerous measurement approaches to capture COVID-19 deaths. The underlying accuracy of these approaches depends on a broad range of factors such as the degree to which mortality- and health registers are integrated and to what extent COVID-19 infections are indeed detected, which, to a significant extent, depends on the underlying test capacity Kiang et al. (2020); Clark and Turner (2021)

While the primary focus of this paper is to study non COVID-19 excess deaths that are an indirect result of COVID-19 disrupting the healthcare system, we nevertheless aim to compare the indirect death toll that COVID-19 has caused with a direct measure of the COVID-19 death toll in order to quantify the relative effect.

We express our main estimate of the non-COVID-19 excess deaths among hospital patients

seeking medical help for reasons unrelated to COVID-19 as a relative measure relative to the estimate of COVID-19 deaths. We do so by leveraging various measures of COVID-19 deaths that have been derived from UK data providing us with an upper and a lower bound estimate.

In the UK there are four main measures that have been regularly constructed and reported. Table B.1 provides an overview of the cumulative deaths reported from March 2020 to February 2021. Figure B.1 provides the aggregate time series.

We note that the measure capturing deaths with COVID-19 being mentioned on the death certificate is the most comprehensive COVID-19 death measure over the time period with an estimate 127,475 deaths. This contrasts with the measure of excess deaths that is being constructed by the Office of National Statistics which stands at 102,585.

The reason why the data based on COVID-19 mentioned on death certificate produces notably larger death figures than, say, the number of deaths within 28 days or 60 days of a positive COVID-19 test is due to the way the death certificate data can be coded. The death certificate is produced by a doctor or coroner certifying a death. They can record more than one health condition or event on the form which capture a sequence of health conditions or events leading directly to death or other health conditions that contributed to the death but were not part of the direct sequence. This may also included suspected diagnosis that may not have been confirmed.

As a result many deaths are coded as involving a COVID-19 diagnosis or suspected COVID-19 diagnosis either as a direct- or indirect condition. This produces death figures that are notably larger.

Our estimates in Figure B.1 suggest that our non COVID-19 excess death estimate implies that for every 25 to 32 deaths that can be linked to COVID-19, there is at least one excess death among patients seeking medical help for reasons unrelated to COVID-19. This suggests sizeable negative externalities with care for COVID-19 patients likely crowding out care for non COVID-19 patients. The subsequent analysis documents that indeed, at the provider level, the non COVID-19 excess deaths are strongly increasing during times when hospitals are hit with pressures taking the form of many hospital cases with COVID-19 or due to large increase in COVID-19 admissions.

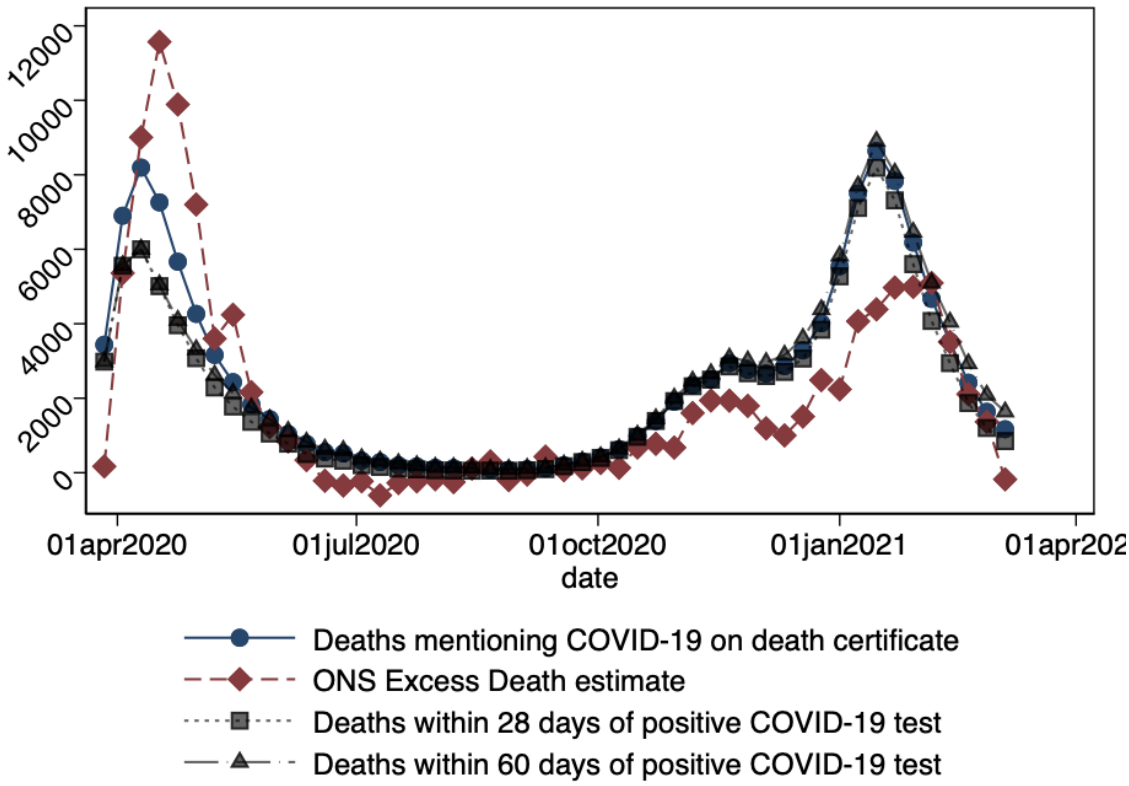
Appendix B: Additional tables and figures

Table B.1—: Estimated total COVID-19 deaths across measurement methods from March 2020 to February 2021

	Deaths	$\frac{\text{COVID-19 deaths}}{\text{non COVID-19 excess deaths}}$
ONS Excess Deaths	102,585	25.63
Deaths mentioning COVID-19 on death certificate	127,475	31.85
Deaths within 28 days of positive COVID-19 test	108,754	27.17
Deaths within 60 days of positive COVID-19 test	124,210	31.04

Notes: Cumulative estimates of COVID-19 deaths reported across different data sources for England from March 2020 to February 2021 (inclusive).

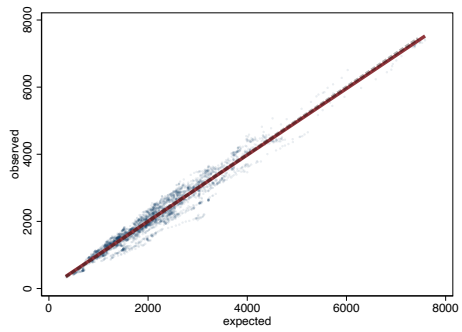
Figure B.1. : Comparison of COVID-19 deaths data across different data products



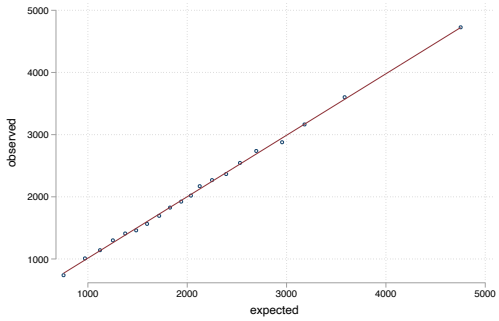
Notes: Figure shows the relationship between COVID-19 cases in the community or catchment areas of NHS providers (panel A) or COVID-19 hospital admissions (panel B) and the number of COVID-19 hospital episodes that have been removed from the SHMI mortality modelling. The figure suggests a tight fit with a near one-to-one relationship between individuals admitted to hospital with a COVID-19 infection (panel B) and the number of hospital spells excluded for the estimation of non COVID-19 excess mortality. This suggests that the SHMI product is cleaned and fully focusing on patients that seek medical help for reasons unrelated to COVID-19.

Figure B.2. : Relationship between observed vs expected deaths in the SHMI data

Panel A: Scatterplot

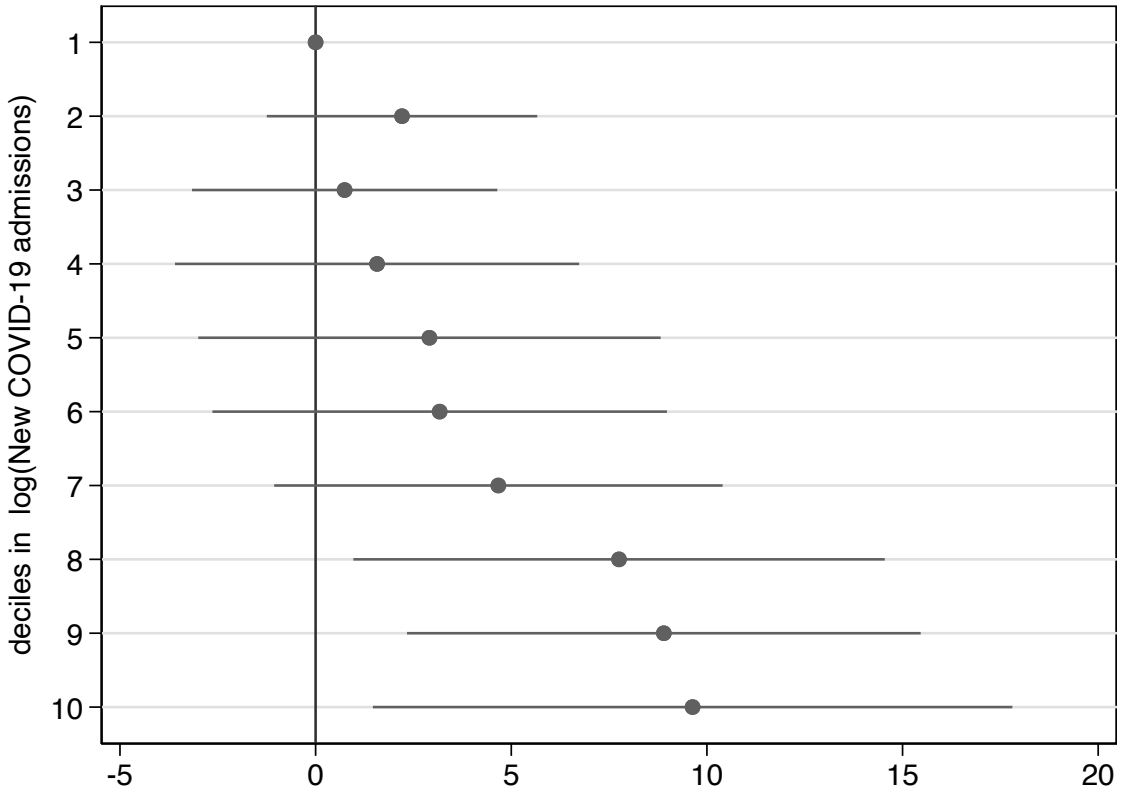


Panel B: Binned scatterplot



Notes: Figure display the relationship between observed and expected deaths in the SHMI data. We note that there is a tight relationship. In the left panel we plot a simple scatterplot with the solid line indicating the linear regression fit and the dashed line representing a 45 degree line. The linear regression fit and the 45 degree line coincide nearly. The right panel presents a binned scatterplot. In both instances it becomes obvious that the observed and expected deaths match closely.

Figure B.3. : Impact of COVID-19 pressures on non COVID-19 excess mortality: effect across different deciles of the COVID-pressure intensity



Notes: Figure presents heterogenous treatment effects capturing the impact of COVID-19 pressures on excess mortality. The dependent variable measures the month-on-month changes in excess mortality to proxy month-specific excess mortality. All regressions control for provider fixed effects , time fixed effects and provider-specific linear trends along with as well as month-on-month changes in number of spells. 90% confidence intervals obtained from clustering standard errors at the provider level are indicated.

Table B.2—: Impact of COVID-19 health care system pressures on non COVID-19 excess deaths *without controlling for community COVID-19 transmission*

	(1)	(2)	(3)	(4)	(5)
Panel A:					
log(COVID-19 cases in hospital$_t$)	1.825	2.647**	2.573**	2.580**	2.782**
	(1.234)	(1.187)	(1.190)	(1.199)	(1.158)
Observations	1480	1480	1457	1457	1457
Clusters	124	124	122	122	122
Panel B:					
log(New COVID-19 admissions$_t$)	3.747***	4.658***	4.328***	4.346***	4.550***
	(1.360)	(1.305)	(1.301)	(1.311)	(1.504)
Observations	1480	1480	1457	1457	1457
Clusters	124	124	122	122	122
Panel C:					
log(COVID-19 cases on ventilators$_t$)	2.382	3.853***	3.836***	3.870***	4.073**
	(1.867)	(1.379)	(1.387)	(1.400)	(1.615)
Observations	1480	1480	1457	1457	1457
Clusters	124	124	122	122	122
Provider FE	X	X	X	X	X
Time FE	X	X	X	X	X
ΔSpells$_{p,t}$		X	X	X	X
Excess deaths$_{p,t-13}$			X		
Obs$_{p,t-13}$ and Exp$_{p,t-13}$				X	X
Provider specific linear time trend					X

Notes: Regressions present results at the NHS provider level documenting the relationship between different measures of COVID-19 pressures at the provider level and overall excess deaths reported in a given month. The excess death measure captures month-on-month changes in excess death constructed from the twelve month cumulative windows. Across columns subsequently more control variables are added that aim to capture the potential confounding effect that base effects could have on the estimates. Standard errors are clustered at the provider level with stars indicating *** p< 0.01, ** p< 0.05, * p< 0.1.

Table B.3—: Impact of COVID-19 health care system pressures on non COVID-19 excess deaths *with controlling for community COVID-19 transmission*

	(1)	(2)	(3)	(4)	(5)
Panel A:					
log(COVID-19 cases in hospital$_t$)	0.241	1.538	1.409	1.416	2.323
	(1.593)	(1.535)	(1.528)	(1.540)	(1.506)
Observations	1434	1434	1422	1422	1422
Clusters	123	123	122	122	122
Panel B:					
log(New COVID-19 admissions$_t$)	2.118	3.424**	3.105*	3.123*	3.972*
	(1.672)	(1.659)	(1.653)	(1.665)	(2.029)
Observations	1434	1434	1422	1422	1422
Clusters	123	123	122	122	122
Panel C:					
log(COVID-19 cases on ventilators$_t$)	2.063	3.601**	3.678**	3.713**	3.950**
	(1.971)	(1.470)	(1.467)	(1.477)	(1.693)
Observations	1434	1434	1422	1422	1422
Clusters	123	123	122	122	122
Provider FE	X	X	X	X	X
Time FE	X	X	X	X	X
Community Transmission	X	X	X	X	X
ΔSpells$_{p,t}$		X	X	X	X
Excess deaths$_{p,t-13}$			X		
Obs$_{p,t-13}$ and Exp$_{p,t-13}$				X	X
Provider specific linear time trend					X

Notes: Regressions present results at the NHS provider level documenting the relationship between different measures of COVID-19 pressures at the provider level and overall excess deaths reported in a given month. The excess death measure captures month-on-month changes in excess death constructed from the twelve month cumulative windows. Across columns subsequently more control variables are added that aim to capture the potential confounding effect that base effects could have on the estimates. Standard errors are clustered at the provider level with stars indicating *** p< 0.01, ** p< 0.05, * p< 0.1.

Table B.4—: Impact of COVID-19 health care system pressures and non COVID-19 excess mortality

	COVID-19 pressures measured in the last ... months					
	0	1	2	3	6	9
	(1)	(2)	(3)	(4)	(5)	(5)
Panel A:						
log(confirmed COVID-19 patients in hospital)	0.004**	0.006**	0.007*	0.008*	0.005	0.003
	(0.002)	(0.003)	(0.004)	(0.005)	(0.010)	(0.012)
Observations	1490	1490	1490	1490	1490	1490
Clusters	126	126	126	126	126	126
Panel B:						
log(New COVID-19 hospital admissions)	0.005**	0.008***	0.012***	0.016***	0.019*	0.021
	(0.002)	(0.003)	(0.004)	(0.006)	(0.011)	(0.015)
Observations	1490	1490	1490	1490	1490	1490
Clusters	126	126	126	126	126	126
Panel C:						
log(# of COVID-19 cases in ventilator beds)	0.003*	0.005**	0.005**	0.006**	0.009*	0.010*
	(0.002)	(0.002)	(0.002)	(0.003)	(0.005)	(0.006)
Observations	1490	1490	1490	1490	1490	1490
Clusters	126	126	126	126	126	126
Provider FE	X	X	X	X	X	X
Time FE	X	X	X	X	X	X
Spells	X	X	X	X	X	X

Notes: Regressions present results at the NHS provider level documenting a positive relationship between COVID-19 pressures measured in different ways across Panels A - D and diagnostic-specific excess mortality for non COVID-19 patients. The dependent variable measures the log difference in observed versus expected number of deaths. The expected number of deaths is constructed by NHS Digital (2021) based on case-level data. The right hand-side measures across columns are in logs measuring the COVID-19 pressures cumulative over the number of months indicated in the column head. That is, column (3) studies how COVID-19 pressures measured at the provider level affects excess deaths over the last 12 months. Standard errors are clustered at the provider level with stars indicating *** p< 0.01, ** p< 0.05, * p< 0.1.

Table B.5—: Impact of COVID-19 health care system pressures and non COVID-19 mortality – controlling for expected mortality

	COVID-19 pressures measured in the last ... months					
	0	1	2	3	6	9
	(1)	(2)	(3)	(4)	(5)	(5)
Panel A:						
log(COVID-19 cases in hospital)	0.005**	0.006**	0.007*	0.008	0.004	0.002
	(0.002)	(0.002)	(0.004)	(0.005)	(0.010)	(0.012)
log(expected deaths)	0.856***	0.857***	0.858***	0.858***	0.858***	0.857***
	(0.079)	(0.079)	(0.079)	(0.080)	(0.080)	(0.079)
Observations	1490	1490	1490	1490	1490	1490
Clusters	126	126	126	126	126	126
Panel B:						
log(New COVID-19 admissions)	0.005**	0.008**	0.011***	0.015**	0.017	0.019
	(0.002)	(0.003)	(0.004)	(0.006)	(0.011)	(0.014)
log(expected deaths)	0.857***	0.858***	0.860***	0.861***	0.861***	0.860***
	(0.079)	(0.079)	(0.079)	(0.080)	(0.080)	(0.080)
Observations	1490	1490	1490	1490	1490	1490
Clusters	126	126	126	126	126	126
Panel C:						
log(COVID-19 cases on ventilators)	0.003**	0.005**	0.005**	0.006**	0.008*	0.009*
	(0.002)	(0.002)	(0.002)	(0.003)	(0.005)	(0.005)
log(expected deaths)	0.856***	0.856***	0.857***	0.858***	0.860***	0.860***
	(0.079)	(0.078)	(0.078)	(0.078)	(0.078)	(0.078)
Observations	1490	1490	1490	1490	1490	1490
Clusters	126	126	126	126	126	126
Provider FE	X	X	X	X	X	X
Time FE	X	X	X	X	X	X
Spells	X	X	X	X	X	X

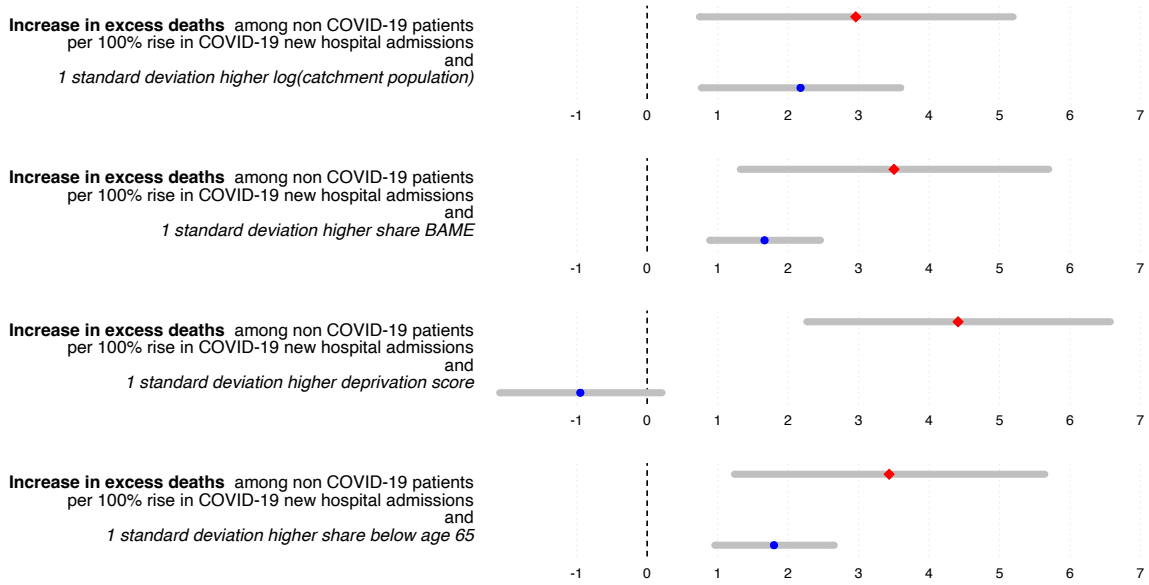
Notes: Regressions present results at the NHS provider level documenting a positive relationship between COVID-19 pressures measured in different ways across Panels A - D and mortality for non COVID-19 patients. The dependent variable measures the log in observed deaths. The expected number of deaths is added as a control variable. The expected number of deaths is constructed by NHS Digital (2021) based on case-level data. The measures across columns are in logs measuring the COVID-19 pressures cumulative over the number of months indicated in the column head. That is, column (3) studies how COVID-19 pressures measured at the provider level affects excess deaths over the last 12 months. Standard errors are clustered at the provider level with stars indicating *** p< 0.01, ** p< 0.05, * p< 0.1.

Table B.6—: Impact of COVID-19 health care system pressures and non COVID-19 death rates

	COVID-19 pressures measured in the last ... months					
	0	1	2	3	6	9
	(1)	(2)	(3)	(4)	(5)	(5)
Panel A:						
log(COVID-19 cases in hospital)	0.015**	0.021**	0.027**	0.034*	0.028	0.022
	(0.007)	(0.010)	(0.013)	(0.018)	(0.034)	(0.044)
Expected deaths / # of spells	0.953***	0.954***	0.954***	0.954***	0.954***	0.954***
	(0.113)	(0.113)	(0.113)	(0.114)	(0.114)	(0.113)
Observations	1490	1490	1490	1490	1490	1490
Clusters	126	126	126	126	126	126
Panel B:						
log(New COVID-19 admissions)	0.016*	0.028**	0.041***	0.054***	0.064*	0.064
	(0.008)	(0.011)	(0.015)	(0.020)	(0.039)	(0.051)
Expected deaths / # of spells	0.954***	0.955***	0.955***	0.956***	0.956***	0.955***
	(0.113)	(0.113)	(0.113)	(0.114)	(0.114)	(0.114)
Observations	1490	1490	1490	1490	1490	1490
Clusters	126	126	126	126	126	126
Panel C:						
log(COVID-19 cases on ventilators)	0.012**	0.018***	0.021***	0.025**	0.038**	0.043**
	(0.006)	(0.006)	(0.008)	(0.010)	(0.016)	(0.018)
Expected deaths / # of spells	0.953***	0.953***	0.953***	0.954***	0.955***	0.956***
	(0.112)	(0.112)	(0.112)	(0.112)	(0.111)	(0.111)
Observations	1490	1490	1490	1490	1490	1490
Clusters	126	126	126	126	126	126
Provider FE	X	X	X	X	X	X
Time FE	X	X	X	X	X	X

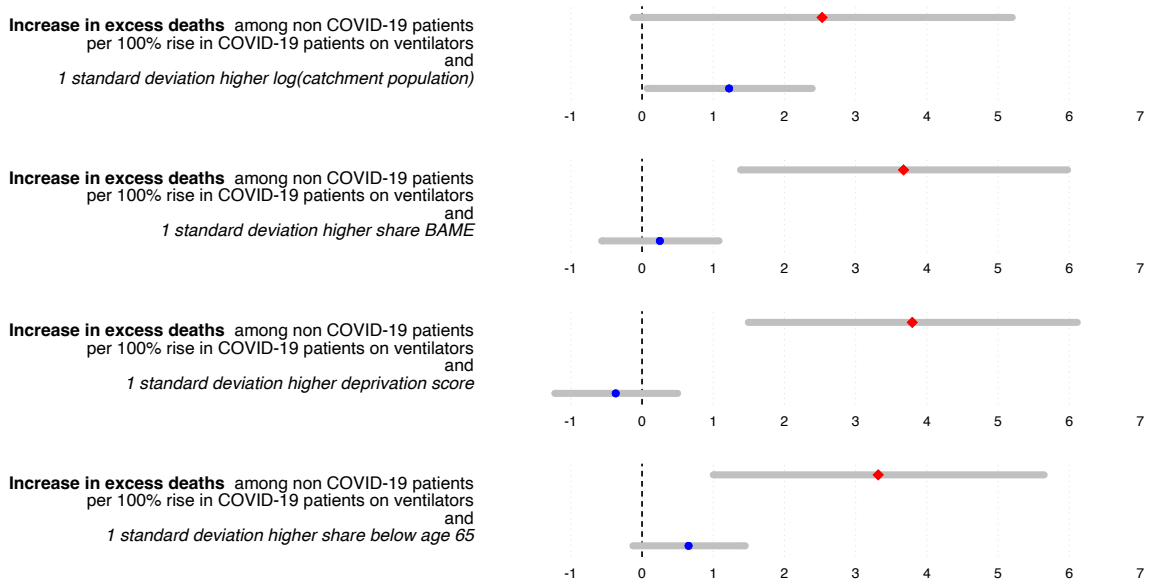
Notes: Regressions present results at the NHS provider level documenting a positive relationship between COVID-19 pressures measured in different ways across Panels A - D and mortality for non COVID-19 patients. The dependent variable measures the share of hospital admissions that result in a death. The expected share of deaths per admission is added as a control variable. The expected number of deaths is constructed by NHS Digital (2021) based on case-level data. The measures across columns are in logs measuring the COVID-19 pressures cumulative over the number of months indicated in the column head. That is, column (3) studies how COVID-19 pressures measured at the provider level affects excess deaths over the last 12 months. Standard errors are clustered at the provider level with stars indicating *** p< 0.01, ** p< 0.05, * p< 0.1.

Figure B.4. : Impact on non COVID-19 excess mortality of average new daily COVID-19 hospital admissions depending on characteristics of the catchment area of NHS healthcare providers.



Notes: The figure plots the coefficients of the interaction term from regression estimates at the NHS provider level. The point estimate captures the effect of a 100% change in COVID-19 pressures combined with a one standard deviation increase in the catchment area characteristic on the number of excess deaths in a given month among patients seeking medical help for reasons unrelated to COVID-19. We measure COVID-19 pressures as the monthly average new daily COVID-19 hospital admissions in a given month. The catchment area characteristics are the deprivation score, the share of Black or Asian, the log of total population, and the share of people below age 65 in the catchment area of the provider. All regressions control for NHS provider fixed effects and time fixed effects. 90% confidence intervals obtained from clustering standard errors at the provider level are indicated.

Figure B.5. : Impact on non COVID-19 excess mortality of beds with ventilator occupied by COVID-19 patients depending on characteristics of the catchment area of NHS healthcare providers.



Notes: The figure plots the coefficients of the interaction term from regression estimates at the NHS provider level. The point estimate captures the effect of a 100% change in COVID-19 pressures combined with a one standard deviation increase in the catchment area characteristic on the number of excess deaths in a given month among patients seeking medical help for reasons unrelated to COVID-19. We measure COVID-19 pressures as beds with ventilator occupied by COVID-19 patients in a given month. The catchment area characteristics are the deprivation score, the share of Black or Asian, the log of total population, and the share of people below age 65 in the catchment area of the provider. All regressions control for NHS provider fixed effects and time fixed effects.