Title: Hospital Quality and Patient Outcomes during the Coronavirus Pandemic

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Introduction:

The COVID-19 pandemic has brought extreme strain on hospital and healthcare systems across the United States. Variation in reported mortality measures suggests that some hospitals were prepared to deal with the influx of patients and medical uncertainty more so than others. However, these observational comparisons do not account for the unobserved severity of patients seen, which is a function of both hospital reputation and patient's choice of hospital.

We propose a study to estimate hospital quality responses to the novel coronavirus pandemic, making appropriate adjustments for known risk-factors (e.g. patient age, gender, comorbidities, etc.) while additionally allowing for hospital choice to correlate with unobserved severity. We then propose to use these quality estimates to determine mortality consequences of under-performing hospitals and document populations who are most affected by varying hospital quality, with a focus on the age gradient of mortality.

To our knowledge, this will be the first project to estimate nationwide hospital quality responses to the pandemic, hospital learning to treat COVID-19, hospital capacity impacts, and the subsequent effect that quality has on health outcomes using data that comprise a virtual census of non-government, general acute care hospitals across the US. Previous studies have examined correlation in healthcare service/capital demand on patient mortality outcomes (e.g. Karaca-Mandic et. al. 2020), but do not construct hospital-specific measures of quality of care. Ashe et al. (2020) use a very selected hospital sample over the early phases of the pandemic (ending in April, 2020) correcting for observable but not unobservable patient severity and finds significant variation in hospital specific mortality. Cronin and Evans (2020) examine the relationship between quality and mortality, though focus on the nursing home sector rather than inpatient medical care. An important innovation of our study is to allow for correlation in unobserved patient-mix severity in calculating both hospital quality measures and patient mortality consequences which is absent from this burgeoning literature.

The ultimate purpose of our study is to better understand the demographic disparities in COVID-19 outcomes by analyzing the association between hospital quality and patient mortality. We will use inpatient claims data to conduct the empirical analysis. We plan to address miscoding concerns using a machine learning approach and will estimate hospital quality following the formal outcome-choice model in Geweke, Gowrisankaran and Town (2003), henceforth denoted as ***GGT***.

Data:

We propose using the Center for Medicare and Medicaid Services (CMS), MedPAR files which contain 20% random sample of the entire Medicare beneficiaries fee-for service population. We will utilize information on patient demographics, disposition, and identify COVID-19 using ICD-10 code (recently added to the coding system). These data also contain hospital identifiers and information on the beneficiary's home ZIP code which is important for identification in our model. We will use data from 2019 and 2020, where the former is needed to control for pre-pandemic hospital specific quality measures. This will also allow for supplementary analyses looking at differences in pneumonia treatment quality and COVID-19 treatment quality within hospitals.

Empirical Approach:

The empirical approach can be broken down into a three-step procedure: miscoding correction, quality estimation, and mortality consequences.

Miscoding Correction

It is very likely that COVID-19 diagnoses are miscoded in the data, especially early in the pandemic when the disease and recognition was not well understood. This will naturally lead to early-period under identification of cases.[1] To address this problem of miscoding, we propose a machine learning prediction approach. Specifically, we will use data from well into the pandemic to build a prediction model using ICD-10 codes as labels and patient characteristics as model features. We will then apply the trained algorithm to the early pandemic sample in order to classify which respiratory admissions were actually COVID-19 related.

Hospital Quality Estimation

We will estimate hospital specific quality using the two-stage model in GGT. In the first stage, patients with COVID-19 symptoms choose a hospital for treatment. In the second stage, patients receive treatment, and a mortality outcome is observed. The model allows for both the mortality outcome and patient choice to be a function of patient illness severity which is unobserved to the econometrician.

Identification of hospital quality requires an exclusion restriction variable that is correlated with hospital choice but not with patient severity conditional on observables. As in GGT, we propose using patient ZIP code data and calculating 'distance to hospital' as the instrument. However, noting an uptick in capacity constraints and hospital transfers,[2] we will also consider using variation in timing around hospital bed capacity limits, hospital concentration measures in a market, and county or hospital-level policies regarding admissions during the pandemic. We will also explore using variation in ambulance referral regions following Doyle et. al. (2015) and Hull (2020).

We will use a Bayesian inference approach in estimating the underlying model parameters (i.e. hospital specific quality), employing Markov Chain Monte Carlo techniques to simulate parameters and latent variables conditional on data. This procedure is documented in the GGT appendix and additionally in Marquardt, Gowrisankaran, and Town (2019).

Mortality Consequences

Finally, we can combine the data and model estimates to measure the mortality consequences of patient hospital selection. That is, we will measure the number of excessive deaths attributable to under-performing hospitals. We will also explore the patient demographic correlates of excess deaths. With a focus on elder population groups, our mortality consequence analysis will help us disentangle how much of the COVID-19 mortality difference across age is driven by observed risk factors, underlying severity, or hospital choice.

Relevance:

While there are many motivations for this project, the key purpose is to better understand reasons for COVID-19 mortality rates, with a focus on the age-specific mortality gradient. Specifically, we ask how hospital quality impacts patient outcomes during the Coronavirus pandemic, and how much of this can explain the large mortality rates in older populations. Our results may help guide federal funding health care allocation decisions and/or public health policies to protect vulnerable age groups. The effectiveness of such policies depends on understanding the role that hospital quality plays in determining patient health outcomes, which is exactly what this study aims to do.

[1] *The Washington Post* (April 2020) provides a discussion on COVID-19 under identification.
[2] See Evans et. al. (Oct 2020) and Sayers & Machelor (July 2020) for issues relating to Covid-19 patient transfers.

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