

Original Research Article

# Demographics matter: the potentially disproportionate effect of COVID-19 on hospital ratings

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## Abstract

**Objective:** To identify how features of the community in which a hospital serves differentially relate to its patients' experiences based on the quality of that hospital.

**Design:** A Finite Mixture Model (FMM) is used to uncover a mix of two latent groups of hospitals that differ in quality. In the FMM, a multinomial logistic equation relates hospital-level factors to the odds of being in either group. A multiple linear regression relates the characteristics of communities served by hospitals to the patients' expected ratings of their experiences at hospitals in each group. Thus, this association potentially varies with hospital quality. The analysis was conducted via Stata.

**Setting:** Hospital ratings are measured by Hospital Compare using the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey, a patient satisfaction survey required by the Centers for Medicare and Medicaid Services for hospitals in the USA.

**Participants:** 2,816 Medicare-certified acute care hospitals across all US states.

**Intervention:** None.

**Main Outcome Measure:** Differences in the marginal impacts of key community demographics on patient experiences between the two groups of hospitals.

**Results:** We provide evidence that low-rated hospitals have much more variability in patient experience ratings than high-rated ones. Moreover, the experiences at low-rated hospitals are more sensitive to county demographic factors, which means exogenous shocks, like coronavirus disease-2019 (COVID-19), will likely affect these hospitals differently, as such shocks are known to disproportionately affect their communities.

**Conclusions:** Our results imply that low-rated hospitals with more variability in their HCAHPS responses are more likely to face adverse patient experiences due to COVID-19 than high-rated hospitals. Pandemics like COVID-19 create conditions that intensify the already high demands placed on hospitals and care providers and make it even more challenging to deliver quality care.

**Key words:** HCAHPS, hospital ratings, community demographics, COVID-19

## Introduction

Under the Hospital Value-Based Purchasing (VBP) Program, Medicare makes incentive payments to hospitals based on how well they

perform on each measure of the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey and/or how much they improve their performance on each measure compared to

their performance during a baseline period. The goal of HCAHPS is to promote consumer choice, public accountability and greater transparency in health care. Daily, more than 30 000 patients receive HCAHPS surveys about their recent hospital experience, and more than 8400 patients complete it [1]. In July 2016, the Centers for Medicare and Medicaid Services (CMS) began displaying HCAHPS Star Ratings on the ‘Hospital Compare’ website as part of the initiative to add five-star quality ratings of hospitals. Hospitals strive to sustain high ratings to leverage competition to lower costs and improve care quality. Consumers and patient advocates point to ‘Hospital Compare’ and its Star Ratings as important resources and rely on the latest data to make informed choices.

What happens when a pandemic strains resources particularly among hospitals located in densely populated urban centers? This paper examines the demographic and market trends that drive differences in HCAHPS results to forecast how the aftermath of the coronavirus disease-2019 (COVID-19) pandemic will impact hospital ratings. It contributes to the existing literature by empirically assessing the relationship between a hospital’s local community demographics and its patients’ experience ratings for different groups of hospitals distinct in quality. The findings reveal that communities with high rates of COVID-19 infections are more likely to be served by lower-quality hospitals, which, in turn, are linked to the high rates of poverty in those areas. Overall, this lack of resources ends up exacerbating health disparities.

We begin by providing a background on HCAHPS and the significance of Star Ratings. We then discuss theoretical aspects for addressing stakeholders in the clinical and community-based environment. Next, we model the heterogeneous distribution of HCAHPS ratings in relation to the market and demographic factors and infer how it would be affected by a major shock like COVID-19. Finally, we present our conclusions and provide directions for future research.

## HCAHPS survey

The basic sampling procedure for HCAHPS is drawing a monthly random sample of eligible discharges, except for smaller hospitals that survey all HCAHPS-eligible discharges. Responses about patient experiences at a given hospital are collected throughout each month of the 12-month reporting period and are aggregated quarterly for each hospital. The survey response rate and the number of completed surveys are reported on the ‘Hospital Compare’ website [2]. CMS linearly transforms responses to numerical values and adjusts for differences in patient mix and survey mode across the last four quarters to produce a score between 0 and 100 for 10 domains of patient experience, which are publicly reported for each participating hospital. The domains are communication with nurses and doctors, hospital staff responsiveness, communication about medicine, cleanliness and quietness of hospital environment, discharge information, care transition, hospital rating, and recommendation of hospital. CMS reports significant (at the 1% level) patient-level correlations among these domains, ranging from 0.13 to 0.77, based on 2.9 million patients discharged between July 2018 and June 2019. Hospitals and researchers have relied on these scores to assess patient experience [e.g. 3–5].

CMS objectively assesses six outcome and process of care measures: Mortality, Patient Safety, Readmission Rates, Effectiveness of Care, Timeliness of Care and Efficient Use of Medical Imaging. Together with the HCAHPS patient experience measures, CMS

provides an overall summary of healthcare quality at participating hospitals via Star Ratings. These ratings drive systematic improvements in care and safety as hospitals strive to sustain high ratings and further differentiate their services based on patient satisfaction [6]. Cross-domain analyses by Press Ganey [7] have shown that hospitals in the top HCAHPS quartile with better patient experience also had better records in safety, technical quality, length of stay and readmission rates.

## Theoretical background

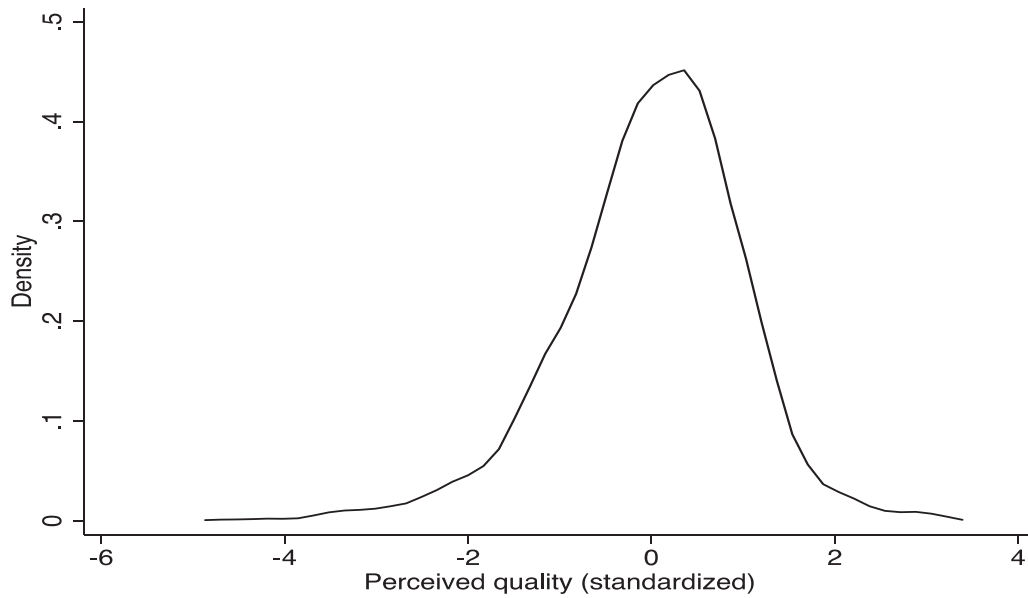
Healthcare quality requires a multidimensional definition that encompasses various healthcare stakeholder needs and expectations, including effective care that contributes to the patient well-being and satisfaction [8, 9]. We follow the community-based stakeholder approach, a patient-focused group that provides important insights into hospital performance within the broader continuum of care used in previous research [10, 11]. A variant of this framework was recently used in a study involving executive responses to stakeholders during the *E. coli* outbreak in 2015–2017 [12].

Key stakeholders in the current study include CMS, the regulatory agency with a fiduciary responsibility for aggregating data from patients aimed at developing population-level metrics for aligning financial incentives with quality of care based on hospital ratings. Others are patients who receive care services from providers and are the beneficiary customers of the payers. Research shows that satisfaction with a prior hospital admission has a large impact on future hospital choice [13], supporting the claim that patients tend to be accurate in their assessments of quality despite a lack of medical or clinical experience. Patients also make sound choices based on personal recommendations and word-of-mouth marketing [14].

Patients’ willingness to recommend hospitals is critical, especially in large urban areas with highly heterogeneous patient populations, since potentially lower ratings could affect hospitals’ reimbursement and bottom-line outcomes. Researchers [15] analyzed surveys from 934 800 patients in 3907 hospitals in more than 3100 counties and found lower HCAHPS scores are clustered in heterogeneous population-dense areas. Another study examined county-level data including population density, population diversity and hospital structural factors as predictors of patient satisfaction and found that county-level factors accounted for 30% and 16% of the variability in patient satisfaction on the HCAHPS measures of doctor and nurse communication, respectively [16]. We extend the scope of these findings by examining the effects of demographic characteristics on hospital ratings and provide a forecast for how a major shock like COVID-19 could further affect these ratings.

## Study design and methods

We analyze a sample of 2816 Medicare-certified acute care hospitals across the USA, using January–December 2018 CMS Hospital Compare datasets merged with county-level sociodemographic data. We use these data to uncover groups of hospitals that are different in their distribution of hospital quality and then relate features of the community in which hospitals serve to their patient experience rating in each group. We assess patient experience using a composite of 10 HCAHPS linear scores, by averaging the scores and standardizing the result. Figure 1 provides the distribution of patient experience rating (i.e. perceived hospital quality). It appears approximately normal with a slight negative skew, perhaps because of a separate cluster of poor experiences likely reported by patients at lower quality hospitals.



**Figure 1** Distribution of patients' perceived quality of hospitals.

We use the Finite Mixture Model (FMM), described in Greene [17], as a parsimonious and efficient means of simultaneously estimating potentially several regressions of patient ratings on community factors for different groups of hospital quality. Groups are separated in a non-arbitrary, data-driven manner. Formally, the density  $f$  of patient experience rating  $y$  comes from a mix of  $G$  underlying groups of hospitals of distinct quality. Thus, the approximately normal density  $f(y)$  we observed in Figure 1 is modeled as a weighted average of two or more normal densities of  $y$  in groups  $c = 1, 2, \dots, G$ , as follows:

$$f(y) = \sum_{c=1}^G \pi_c \cdot f(y|\mu_c, \sigma_c^2), \text{ where } \sum_{c=1}^G \pi_c = 1$$

Here,  $\pi_c$  is the proportion of hospitals in group  $c$ , in which  $y$  averages  $\mu_c$  and varies by  $\sigma_c$ .

Hospitals clearly do not only differ in quality based on patient experience. Thus, we further distinguish hospital quality groups by specifying  $\pi_c$  as a multinomial logistic function of hospital characteristics  $\mathbf{z}$ , such that the odds of belonging to group  $c$  depends on hospital ownership and a composite of the other six outcome and process of care measures of the Star Ratings. CMS reports each measure as three performance categories (i.e. above, same as or below the national average), which we linearly scored, averaged and then standardized. Our goal is to relate the characteristics of a community served by a hospital to patient experience at that hospital, for different groups of hospital quality. Accordingly, we linearly parameterize the expected patient ratings for each group  $c$  as  $\mu_c = \mathbf{x}'\beta_c$ , where  $\mathbf{x}$  comprises the county-level sociodemographics listed in Table 1, with  $\beta_c$  as the coefficient vector of interest.

It is worth noting that US hospitals have Primary Service Areas that do not entirely correspond with a specific county. Large hospitals and rural community hospitals often serve multiple counties. Small urban hospitals, however, are more likely to serve individual counties. Thus, we use a subsample of 685 such hospitals to estimate the FMM, as a robustness check. Using hospital bed data from HealthData.gov, we define small hospitals as those with fewer than

**Table 1** List of county-level variables and their sources

Variable	Year	Source	Mean
% Females	2018	Census Population Estimates	50.5
% Rural	2010	Census Population Estimates	36.5
% Below age 18 years	2018	Census Population Estimates	22.2
% 65 years and older	2018	Census Population Estimates	17.5
% Non-Hispanic white	2018	Census Population Estimates	72.9
% Unemployed	2018	Bureau of Labor Statistics	4.1
Median household income	2018	Small Area Income and Poverty Estimates	56 548.6
% Completed at least some college	2014–18	ACS, 5-year estimates	61.0
% Single-parent households	2014–18	ACS, 5-year estimates	33.7
% Injury death rate	2014–18	NCHS, Mortality Files	80.0
Primary Care Physician per 1000 residents	2017	Area Health Resource File	2.8
% Uninsured	2017	Small Area Health Insurance Estimates	10.4

200 beds since they are small enough that diseconomies of scale are still expected to occur [18]. This cutoff also roughly corresponds to the sample median size of 195 beds. We define urban hospitals as those located in metropolitan counties, as defined by the US Office of Management and Budget (OMB), but with below-average percentage rural population, since the OMB definition of metropolitan counties undercounts the rural population.

Given the number of groups ( $G$ ), one can estimate all parameters of the FMM (i.e.  $\pi_c$ ,  $\mu_c$ ,  $\sigma_c$ ), by using an E-M (Expectation-Maximization) algorithm to maximize the log-likelihood (LL) function of  $f(y)$ . Fraley and Raftery [19] suggest a small number of groups to avoid failure of the algorithm; thus, we run the algorithm for  $G = 1, 2, \dots, 5$  and select the  $G$  that minimizes the Bayesian Information Criterion (BIC)—a parsimonious model selection criterion. Once the model is estimated for an optimal  $G$ , a hospital with observables  $\{y_i, z_i, x_i\}$  is assigned to group  $c$  if  $\{y_i, z_i, x_i\}$  is most likely derived from a density  $f$  with component parameters  $\mu_c, \sigma_c^2$ .

## Discussion

### Statement of principal findings

Table 2 provides the results of the LLs and BIC from estimating the FMM five times on the full sample and the subsample of small urban hospitals, each time for a different number of groups. By adding groups, we see the LL increases, but at the risk of overfitting. The BIC chooses the  $G$  that balances this tradeoff. It is clear that the smallest BIC value occurs at two latent groups of hospitals.

The average of the estimated  $\pi_c$  for either sample reveals one group comprises the majority (about 60%), namely Group 1. Figure 2 shows the distribution of perceived hospital quality in each group, based on the full sample. It is clear the asymmetry in Figure 1

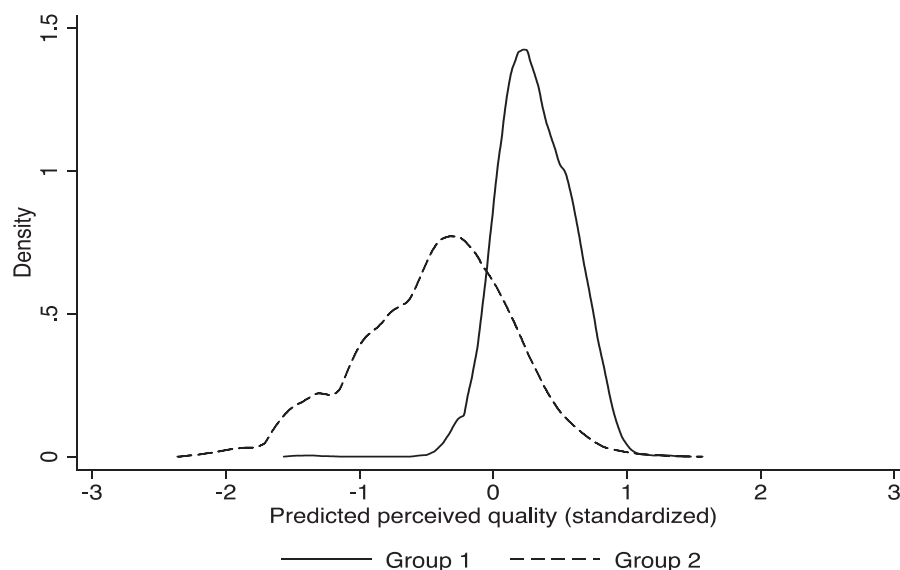
**Table 2** LL and BIC test results

No. of groups tested ( $G$ )	All hospitals		Small urban hospitals	
	LL	BIC	LL	BIC
1	-3640.7	7392.5	-955.1	2001.6
2	-3386.6	7027.5	-856.1	1921.2
3	-3328.9	7055.1	-824.7	1975.8
4	-3288.6	7117.3	-781.2	2006.5
5	-3260.6	7204.4	-765.0	2091.5
Observations	2816		685	

comes from a mixture of two distinct normal densities, such that the lower-peaked density skews the combined density left. Group 1's density corresponds to hospitals with patients having on average more favorable and consistent experiences than hospitals forming Group 2's density.

The coefficients of the hospital characteristics that determine the quality group to which a hospital belongs are displayed in Table 3. For the sample of all hospitals, we find that a one standard deviation improvement in a hospital's outcome/process of care lowers the odds of the hospital being in Group 2 (the low-quality group) versus Group 1 by 85% (i.e.  $0.149-1$ ). Additionally, the odds are highly stacked in favor of not-for-profit and government hospitals belonging to Group 1 (the high-quality group). Results are similar for small urban hospitals.

Table 4 reports the estimated coefficients from the FMM in which we relate 12 key sociodemographic factors to the expected patient ratings of hospitals within each group. The magnitudes of these estimates allow us to compare the importance of each factor across groups. Demographics matter and in different ways depending on a hospital's quality group. For all sampled hospitals, we find the percentage female and percentage rural are the only factors significantly correlated with hospital ratings to a similar extent across groups. Hospitals in counties with higher shares of females and a smaller rural population are rated lower. However, when we examine small urban hospitals, whose patient characteristics are most likely to align with county demographics, we find similar-sized associations for Group 1 only (albeit insignificant for % female). The percentage unemployed and college educated are the only other factors associated with hospital ratings in Group 1 for both samples. While the estimated coefficients for college educated is comparable across groups, unemployment rate only matters to patient ratings for better quality hospitals (i.e. Group 1). Our results based on all sampled hospitals also reveal that hospital ratings are more sensitive to demographic factors in Group 2—the lower quality, more variably rated group. A higher percentage of adults (especially those over 65), racial minorities and potential patients per doctor lead to lower hospital ratings in Group 2 only. Further, the percentage uninsured is positively associated with Group 2 patient ratings, which is not



**Figure 2** Distribution of perceived quality for each latent grouping of hospitals.

**Table 3** Estimated model of group membership, based on  $\pi_c$  in FMM

	All hospitals		Small urban hospitals	
	Log-odds	Odds	Log-odds	Odds
Outcome/process of care	-1.903*** (0.263)	0.149	-1.706*** (0.405)	0.182
Not-for-profit hospital	-3.478*** (0.473)	0.031	-4.010*** (0.895)	0.018
Government hospital	-3.224*** (0.598)	0.039	-2.117** (1.009)	0.120
Observations	2816		685	

Standard errors in parentheses are clustered at the county level. Given two latent groups, group probabilities are based on a binary logit model with Group 1 as the reference group. Outcome/process of care is standardized and is defined such that higher values correspond to better outcomes and process of care. \* $P < 0.10$ , \*\* $P < 0.05$ , \*\*\* $P < 0.01$ .

**Table 4** Estimated model of group means  $\mu_c$  in the FMM

	All hospitals		Small urban hospitals	
	Group 1	Group 2	Group 1	Group 2
% Female	-0.060** (0.025)	-0.083** (0.042)	-0.070 (0.060)	-0.032 (0.070)
% Rural	0.008*** (0.002)	0.009*** (0.003)	0.013*** (0.005)	-0.003 (0.009)
% Under 18 years	0.013 (0.011)	0.054** (0.024)	0.053*** (0.019)	0.158*** (0.049)
% Over 65 years	-0.002 (0.012)	-0.082*** (0.019)	0.006 (0.022)	-0.078** (0.037)
% Non-Hispanic white	0.002 (0.002)	0.023*** (0.005)	0.001 (0.007)	0.039*** (0.009)
% Unemployed	-0.126*** (0.027)	0.008 (0.043)	-0.176*** (0.037)	0.068 (0.058)
% some college	0.011*** (0.004)	0.010 (0.009)	0.014 (0.010)	0.015 (0.017)
Log Household income	-0.305 (0.189)	-0.126 (0.354)	-0.563 (0.359)	-0.458 (0.664)
% Single-parent HH	-0.003 (0.006)	0.014 (0.012)	0.004 (0.013)	0.022 (0.024)
% Injury death rate	0.001 (0.002)	0.002 (0.003)	0.004 (0.004)	-0.004 (0.007)
Log Primary Care Physician ratio	-0.043 (0.079)	0.676*** (0.180)	0.244 (0.153)	1.207*** (0.350)
% Uninsured	0.004 (0.007)	0.048*** (0.012)	0.010 (0.016)	0.057* (0.029)
Average ratings, $E(y \bar{x})$	0.313	-0.426	0.450	-0.255
Rating variability, $\sigma_c^2$	0.415	0.916	0.367	1.335
Group proportion, $E(\pi_c)$	0.607	0.393	0.616	0.384
Observations	2816		685	

Standard errors in parentheses are clustered at the county level. \* $P < 0.10$ , \*\* $P < 0.05$ , \*\*\* $P < 0.01$ .

surprising if the residual variation in the percentage uninsured reflects healthy young adults who are less likely to demand health insurance. The estimates based on the subsample of small urban hospitals largely support these latter findings, with similar or bigger magnitudes of association.

In sum, we find robust evidence that hospitals, particularly low-quality ones, are likely to face adverse patient experiences if there is a negative shock that disproportionately affects older adults (over 65 years), people of color, the unhealthy and those with less access to care.

### Interpretation within the context of the wider literature

These results are simply indicative of what one would expect hospital ratings to look like if, indeed, COVID disproportionately affects certain demographics. We are using 2019 data to make predictions of the change in hospital ratings under COVID based on demographic differences. What the findings do clearly show is that Group 1 hospitals not only score higher ratings on average than Group 2 hospitals but have significantly less variability in patient experience and are less sensitive to demographic factors. These hospitals are likely to have established a stronger brand image than their Group 2 peers and are thus more likely to have poor experiences brought on by capacity strains (e.g. staff shortages, long ER waits, more abrupt care and communication from providers, misdiagnoses, etc.) treated as one-offs than as systemic failures. The power of a strong brand in driving consumer forgiveness after brand transgression was also explored by Tsarenko and Tojib [20]. On the flip side, Group 2 hospitals have more variability in their survey results, which is indicative of a weaker overall quality image, putting them under additional pressure to develop a quality reform plan to better address slowdowns stemming from the COVID-19 pandemic.

Unfortunately, Group 2 hospitals are also more likely to be in lower-income urban areas hit disproportionately hard by COVID-19. Smaller, tighter living quarters, more densely populated neighborhoods and less access to preventative care all contributed to larger and more deadly outbreaks in cities than in rural areas. Frey [21] reports that the counties hit hardest by COVID-19 during the initial peak were predominantly urban and had a higher percentage of non-white residents (44.1%) than the counties that experienced the least prevalence of COVID-19 cases (32.8%). Furthermore, by the time the outbreak had reached New York in March, it was clear that comorbidities exacerbated the impact of COVID-19. According to Sanyaolu *et al.* [22: p. 8], ‘patients with comorbidities have more deteriorating outcomes compared with patients without. COVID-19 patients with history of hypertension, obesity, chronic lung disease, diabetes, and cardiovascular disease have the worst prognosis and most often end up with deteriorating outcomes such as ARDS and pneumonia. Also, elderly patients in long-term care facilities, chronic kidney disease patients, and cancer patients are not only at risk for contracting the virus, but there is a significantly increased risk of death among these groups of patients.’

### Implications for policy, practice and research

Our findings also reveal that minority groups are disproportionately affected by chronic medical conditions and lower access to health care that may signify worse COVID-19 outcomes, with higher death rates in African American, Native American and Latinx communities. In fact, emerging data support the call of the current paper that demographics matter. By April 2020, 97% of disproportionately black counties (counties with more than the national average of black residents) reported at least one case of COVID-19, compared to 80% of all other counties [23]. Twenty-two percent of US counties are in this



category, and 90% of those are in the South. Similar results were reported by the UK's Intensive Care National Audit and Research Centre. Ethnic minorities make up 13% of the UK population. However, by the end of April 2020, 16.2% of patients in hospitals in England who tested positive were from black, Asian and minority ethnic communities [24].

CMS's July 2020 [25] snapshot of COVID-19 reported that by 16 May 2020, over 325 000 Medicare beneficiaries were diagnosed with COVID-19, and nearly 110 000 of those were hospitalized. The snapshot breaks down COVID-19 cases and hospitalizations for Medicare beneficiaries by state, race/ethnicity, dual eligibility for Medicare and Medicaid, age, gender, and urban/rural areas—confirming that COVID-19 disproportionately affects vulnerable populations, particularly racial and ethnic minorities. The highest rates of COVID-19 cases were in black patients, with 1658 cases per 100 000 beneficiaries followed by Hispanic, American Indian/Alaskan Native, Asian, white and then patients listed as 'other or unknown,' further confirming long-standing health-care disparities in these populations.

Patient perceptions of quality associated with what had been routine care have probably changed due to COVID-19, which may affect the way future surveys will be filled out and utilized [26]. Further, patient perceptions of quality and representative surveys should be highly scrutinized as some health-care systems with functioning telemedicine programs were able to make seamless adjustments in their care delivery, while others had to rapidly scale up services with a less than optimal perceived patient experience [27, 28]. In some instances, high proportions of patients for whom English is not the preferred language may influence quality improvement efforts [29].

CMS has recognized that services rendered during the first wave of COVID-19 may affect hospitals' true level of performance on measures such as cost, readmissions and patient experience. As such, it decided to grant exceptions from reporting requirements and extensions for clinicians and providers participating in Medicare quality reporting programs [30] and use data from the 2020 Star Ratings (based on care delivered in 2018) for the 2021 Star Ratings [31].

## Strengths and limitations

The strength of this study lies in how it uses FMM to unveil the heterogeneity in the relationship between community factors and patient experiences, based on hospital quality. In so doing, we are able to identify which group of hospitals and the extent to which they might be susceptible to disproportional effects of COVID-19. While we use key hospital-specific characteristics (e.g. outcome/process of care and hospital ownership type) that determine a hospital's class of quality, other features (e.g. operational structure, teaching status and nurse-patient ratio) are not available in 'Hospital Compare' datasets. Future research can evaluate the demographics of actual service areas served by these hospitals.

Notwithstanding our goal to see how broad differences in pre-COVID hospital communities affect patient ratings, it would also be instructive to check whether the associations we found can be identified from patient-level data. Moreover, the analysis considered only HCAHPS responses from a single year, whereas a longitudinal study may have allowed one to track whether changes in hospital communities over time have led to evolving patient experiences and hospitals transitioning from one quality class to another.

## Conclusions

While the literature on hospital ratings is extensive, there has not been a study that highlights the potential susceptibility of a hospital's

ratings to COVID-19, conditional on the quality of that hospital. This study is a starting point in that direction. The findings of this study imply that lower-rated hospitals with more variability in their HCAHPS responses are more likely to face adverse patient experiences due to COVID-19 than high-quality hospitals. This is caused by a downward cycle in which areas with higher rates of poverty are more likely to be served by these lower-quality hospitals, which do not have the resource capacities to combat the pandemic. Overall, this lack of resources ends up exacerbating health disparities. Pandemics like COVID-19 create conditions that intensify the already high demands placed on hospitals and make it even more challenging to deliver quality care. Hospitals serving a large proportion of minority patients may face greater political and regulatory pressures from local, state and national constituencies to provide better patient experiences for minority patients. Hospitals seeking ways to bolster HCAHPS scores and improve their ratings can respond more equitably to underserved communities and minority groups to reduce health-care disparities. Additionally, examining HCAHPS results over longer time intervals may provide additional insights, especially due to risk perception and communication gaps where hospitals may be blamed for service disruptions, which could further skew HCAHPS results [32].

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All authors contributed equally to this work and approved the final manuscript.

## Ethics and other permissions

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## Data availability

The data used in this article are publicly available but can be shared upon reasonable request to the corresponding author.

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