INTRODUCTION

In past pandemics, vulnerable populations faced greater disease burden and decreased testing and treatment access.1 As coronavirus disease 2019 (COVID-19) spreads in the USA, concern is growing that even the early stages of this pandemic have disproportionately impacted vulnerable communities.2–4 However, the relationship between social vulnerability and COVID-19 diagnosis and mortality in rural and urban communities remains unknown.

METHODS

We performed a county-level, cross-sectional analysis using COVID-19 case and death rates compiled by The New York Times from health agency reports as of April 19, 2020. We stratified counties into quartiles using the U.S. Centers for Disease Control’s Social Vulnerability Index (SVI), a validated measure of community resilience during natural disasters and disease outbreaks across four domains: socioeconomic status, household composition and disability, minority status and language, and housing and transportation.5 We defined urbanicity using the U.S. Department of Agriculture Economic Research Service’s 2013 Urban Influence Codes.6 We merged data sources using Federal Information Processing Standard (FIPS) codes, including counties with a linkable FIPS code and at least one COVID-19 case.

Our primary outcomes were positive tests per capita and COVID-19 deaths per capita. We built population-weighted, quasi-Poisson regression models to compare outcomes between the first and fourth quartiles of counties by SVI and each SVI domain. In secondary analyses, we stratified counties by rural and urban classification. We included state fixed effects to account for heterogeneity in policies and disease spread. We analyzed data with R Statistical Software, version 3.6.3, and considered $P<0.002$ significant after the Bonferroni correction. This study was approved by Partners Healthcare Institutional Review Board.

RESULTS

As of April 19, there were 612,404 confirmed cases and 25,978 COVID-19 deaths across the 2754 (of 3143 total) counties analyzed (mean cases 102.2 per 100,000 [SE 3.8], deaths 4.0 per 100,000 [0.2]). Compared with those in the least vulnerable counties, people in the most vulnerable counties had 1.63-fold greater risk of COVID-19 diagnosis and 1.73-fold greater risk of death (Table 1). When considering only the minority status and language domain, people in the most vulnerable counties had 4.94-fold and 4.74-fold greater risks of COVID-19 diagnosis and death, respectively. Mapping case burden in the most and least vulnerable counties by minority status revealed regional trends of this differential risk (Fig. 1). Similarly, people in the most vulnerable counties by socioeconomic status (relative risks [RR] of 1.42 and 1.71) and housing and transportation (RR 1.52 and 1.32) domains had greater risk of COVID-19 diagnosis and death. Vulnerability by the household composition and disability domain was not associated with differential risk.

These trends persisted among urban counties alone. Among rural counties alone, the most vulnerable counties by minority status and language had greater risk of COVID-19 diagnosis (RR 3.74), while associations with overall SVI, socioeconomic status, and housing and transportation were no longer significant.

DISCUSSION

Greater social vulnerability is associated with increased risk of COVID-19 detection and death. In urban and rural counties alike, this is driven by differences across the minority status and language domain, consistent with preliminary reports of increased COVID-19 prevalence and mortality among minorities.2 Factors such as poverty, unemployment (socioeconomic status domain), crowded housing, and vehicle access (housing and transportation) are important contributors to social vulnerability.
transportation domain) were associated with increased COVID-19 diagnosis and mortality in urban areas. In rural communities, the minority status and language domain persists as a driver of increased COVID-19 cases. The disproportionate impact of COVID-19 on minority and non-English-speaking communities in both urban and rural areas may reflect compounding effects of structural racism, increased burden of chronic disease risk factors, and health care access barriers.

This cross-sectional, county-level study does not allow for causal, individual-level inferences. Analyses did not account for all county-level differences in testing rates or pandemic progression, although state fixed effects accounted for some geographic heterogeneity. As case reporting improves, analyzing more granular groupings of non-metropolitan counties may further elucidate rural trends.

In light of planned federal guidelines for county-level COVID-19 risk stratification and limited national demographic data, our findings reemphasize the need for standardized collection of sociodemographic characteristics. Targeted interventions addressing geographically variable social vulnerabilities may be necessary to improve inequitable outcomes of the COVID-19 pandemic, and health disparities more broadly.
Geographic variation in COVID-19 cases per capita between most and least socially vulnerable counties by minority status and language

Figure 1 The most vulnerable quartile of counties (n = 706, top) and the least vulnerable quartile of counties (n = 625, bottom), as indicated by the minority status and language domain of the U.S. Centers for Disease Control’s Social Vulnerability Index. Counties without linked FIPS code or reported COVID-19 cases were excluded. Darker shades represent counties with more cases per capita.

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**Data Availability** The datasets analyzed during the current study are readily available from the following public repositories. NYTimes: [https://github.com/nytimes/covid-19-data](https://github.com/nytimes/covid-19-data), USDA ERS Urban Influence Codes: [https://www.ers.usda.gov/data-products/urban-influence-codes/](https://www.ers.usda.gov/data-products/urban-influence-codes/), CDC SVI: [https://svi.cdc.gov/data-and-tools-download.html](https://svi.cdc.gov/data-and-tools-download.html), USDA County FIPS Codes: [https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=nrcs143_013697](https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=nrcs143_013697)

**Compliance with Ethical Standards:**

This study was approved by Partners Healthcare Institutional Review Board.

**Conflict of Interest:** Dr. Ganguli reports consulting fees from Haven and Blue Cross Blue Shield Massachusetts for work unrelated to this research. All authors submitted ICMJE Conflict of Interest forms, and no other authors report relevant conflicts of interest.

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**Publisher’s Note:** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.