ORIGINAL RESEARCH

The Population Affected by the Syndemic of COVID-19 and Poverty is More Likely to be Hospitalized with SARS-CoV-2 Pneumonia

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Abstract

Background: Lockdown measures to control COVID-19 have exacerbated the poverty epidemic. We hypothesized that the synergistic interaction of COVID-19 and poverty epidemics favors the development of more severe forms of COVID-19 in the population living in poverty. To test this hypothesis, we assessed whether an ecological association exists between the geographic distribution of hospitalized patients with SARS-CoV-2 pneumonia and markers of poverty in the city of Louisville, KY.

Methods: Using the geomasked home addresses of hospitalized patients with SARS-CoV-2 pneumonia in the city of Louisville, a kernel density heatmap was created. Kulldorff's spatial scan statistic was used to calculate areas of increased risk for SARS-CoV-2 pneumonia hospitalization. Heat maps were created for census tract-level demographics according to income, age, race, and ethnicity to assess whether an ecological association exists with the spatial distribution of SARS-

CoV-2 pneumonia hospitalization.

Results: Four areas of increased risk of hospitalization due to SARS-CoV-2 pneumonia were identified in the western and central sections of the city, with relative risks (RRs) ranging from 2.3 (95% confidence interval (CI): 1.7–3.0) to 3.2 (95% CI: 2.1–5.0) ($p < 0.001$ for each area). Most high-risk areas were associated with areas of the city with low-income populations and black and Hispanic communities but were not associated with areas of older adults.

Conclusion: Residents from low-income areas are almost three times more likely to develop SARS-CoV-2 pneumonia requiring hospitalization. Current efforts to decrease the number of COVID-19 hospitalizations through vaccination of populations at risk should be concentrated in city areas with a low-income level population.

Introduction

Physical distancing and movement restrictions have been applied across the globe in an attempt to control the COVID-19 epidemic. Some governments have issued stay-at-home orders to buy time as the number of hospitalized patients with COVID-19 are overwhelming the health care infrastructure. These lockdown measures have produced significant economic disruption, disproportionately affecting the most vulnerable populations and increasing the number of people affected by the current poverty epidemic.[1]

These two entangled epidemics of COVID-19 and poverty generate the perfect syndemic by exacerbating one another; interventions to control COVID-19 are increasing poverty, and poverty is favoring the transmission of COVID-19. People living in poverty are at increased risk of exposure to SARS-CoV-2 due to factors such as overcrowding, jobs that prevent work from home, and reliance on public transportation.[2, 3] Since poverty is also associated with food insecurity and chronic medical conditions, we hypothesized that the vulnerable low-income population is at increased risk of acquiring COVID-19 and at increased risk of acquiring more severe forms of SARS-CoV-2 pneumonia requiring hospitalization. To test this hypothesis, we evaluated whether an ecological association exists between the geographic distribution of hospitalized patients with SARS-CoV-2 pneumonia and markers of poverty in the city of Louisville, KY.

Methods

Study Design & Patient Population

This study was a retrospective evaluation of hospitalized patients with COVID-19 in all adult hospitals in the city of Louisville, Kentucky, from March 5 to July 1, 2020. A patient was defined as having SARS-CoV-2 pneumonia if an RT-PCR for SARS-CoV-2 was positive at the time of hospitalization and there was evidence of a new pulmonary infiltrate on radiograph and/or computed tomography scan of the chest. Residents of long-term care facilities and patients who resided outside Louisville, KY, at the time of hospitalization were excluded from the study.

Geospatial Epidemiology

The geomasked location of the home address of each patient with SARS-CoV-2 pneumonia was obtained through the US Census Bureau website.[4] A kernel density heatmap was created using each patient's home location at the time of hospitalization. As heatmaps may reflect population density, Kuldorff's spatial scan statistic was used to calculate significant areas of risk for hospitalization due to SARS-CoV-2 pneumonia, ac-

counting for the underlying population distribution.[5] Heatmaps based on census-tract level data were created for the following variables: poverty, black race and/or Hispanic ethnicity, and age of 65 years or older.

Human Subjects Protection

The study was approved by the Institutional Review Board (IRB) at the University of Louisville Human Subjects Research Protection Program Office (IRB number 20.0257) and by the research offices at each participating hospital. The study was exempt from informed consent.

Study Coordinating Center

The University of Louisville Center of Excellence for Research in Infectious Diseases directed all operational and data-related aspects of the study (www.ceridlouisville.org).

Results

A total of 515 hospitalized patients with SARS-CoV-2 pneumonia were included in the study. Four areas of increased risk of hospitalization due to SARS-CoV-2 pneumonia were identified in the city's western and central sections. Residents living in each of these four areas had an increased risk of hospitalization due to SARS-CoV-2 pneumonia ranging from 2.3 (95% CI: 1.7–3.0) to 3.2 (95% CI: 2.1–5.0) times that of residents outside these areas (**Figure 1A**). These high-risk areas were associated with areas of the city with low-income populations (**Figure 1B**) and black and Hispanic communities (**Figure 1C**). One area with a relative risk of 2.4 (95% CI: 4.6–3.5) was associated with areas of older adults (**Figure 1D**).

Discussion

This study indicates that the home addresses of hospitalized patients with SARS-CoV-2 pneumonia form clusters in areas of Louisville occupied by residents of low socioeconomic status. Additionally, large portions of the populations of these areas are black and/or Hispanic. The clinical spectrum of COVID-19 ranges from asymptomatic and mild infections managed in the ambulatory setting to SARS-CoV-2 pneumonia requiring hospitalization in medical wards or ICUs. Our data suggest that poverty is a risk factor for COVID-19 infection and a risk factor for SARS-CoV-2 pneumonia requiring hospital care. The association of increased COVID-19 severity and poverty concurs with a recent study associating increased COVID-19 incidence and mortality with a high level of economic inequality.[6]

One important weakness of our data is that the relationship between low income level and COVID-19 severity

Figure 1. Heatmap of patients hospitalized with SARS-CoV-2 pneumonia with four areas of increased risk (1A); four areas of increased risk of hospitalization due to SARS-CoV-2 pneumonia superimposed onto a heatmap of persons living in poverty (1B); four areas of increased risk of hospitalization due to SARS-CoV-2 pneumonia superimposed onto a heatmap of Black/African American and/or Hispanic persons (1C); four areas of increased risk of hospitalization due to SARS-CoV-2 pneumonia superimposed onto a heatmap of older adult persons (1D).

was evaluated at a population level. Therefore, no conclusion can be drawn about individual hospitalized patients. Nevertheless, the health inequities highlighted by the incidence of COVID-19 in Louisville, with increased severity of disease in low-income, working-class communities, are likely generalizable to low-income communities in other cities.[7]

In the United States, approximately 40 million people are living in poverty.[8] Implementing immediate actions to combat the current syndemic of COVID-19 and poverty is challenging since restoring economic opportunities will take time. However, with the development of COVID-19 vaccines, an opportunity exists to direct vaccination efforts towards low-income communities. This will benefit the populations at higher risk of infec-

tion and severe disease and lessen COVID-19-related inequities.

The COVID-19 epidemic is overwhelming the health-care system in terms of hospital bed capacity, equipment supply, and the healthcare personnel needed to care for the patients. Vaccination campaigns in low-income communities are likely to be the most effective way to decrease the number of hospitalizations due to COVID-19.

In conclusion, an association exists between poverty and severe clinical forms of COVID-19. The syndemic of COVID-19 and poverty is increasing the number of hospitalized patients with SARS-CoV-2 pneumonia. Prevention efforts should be concentrated in populations of low socioeconomic status.

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Appendix: Supplemental Figures

Figure 2. Incidence of SARS-CoV-2 infection by population density in the city of Louisville, KY. Dashed circles represent areas of increased relative risk compared to other areas of the city.

Figure 3. Incidence of SARS-CoV-2 infection by percentage of population in poverty in the city of Louisville, KY. Dashed circles represent areas of increased relative risk compared to other areas of the city.

Figure 4. Incidence of SARS-CoV-2 by percentage of population with Black or African American identity in the city of Louisville, KY. Dashed circles represent areas of increased relative risk compared to other areas of the city.

Figure 5. Incidence of SARS-CoV-2 infection by percentage of population aged 65 or more in the city of Louisville, KY. Dashed circles represent areas of increased relative risk compared to other areas of the city.