

Health service inequalities during the COVID-19 pandemic among elderly people living in large urban and non-urban areas in Florida, USA

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journals.sagepub.com/home/smoXinhua Yu 

Abstract

Objective: Health inequalities were often exacerbated during the emerging epidemic. This study examined urban and non-urban inequalities in health services among COVID-19 patients aged 65 years or above in Florida, USA, from 2 March to 27 May 2020.

Methods: A retrospective time series analysis was conducted using individual patient records. Multivariable Poisson's and logistic models were used to calculate adjusted incidence of COVID-19 and the associated rates of emergency department visits, hospitalizations, and deaths.

Results: As of 27 May 2020, there were 13,659 elderly COVID-19 patients (people aged 65 years or above) in Florida and 14.9% of them died. Elderly people living in small metropolitan areas might be less likely to be confirmed with COVID-19 infection than those living in large metropolitan areas. The emergency department visit and hospitalization rates decreased significantly across metropolitan statuses for both men and women. Those patients living in small metropolitan or rural areas were less likely to be hospitalized than those living in large metropolitan areas (35% and 34% vs 41%). Elderly women aged 75 years or above living in rural areas had 113% higher adjusted incidence of COVID-19 than those living in large metropolitan areas, and the rates of hospitalizations were lower compared with those counterparts living in large metropolitan areas (29% vs 46%; odds ratio: 0.37 (0.25–0.54), $p < 0.001$).

Conclusion: For elderly people living in Florida, USA, those living in small metropolitan or rural areas were less likely to receive adequate health care than those living in large or medium metropolitan areas during the COVID-19 pandemic.

Keywords

COVID-19, geographic disparities, elderly, gender difference, urban rural inequalities, health disparities

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Introduction

Since December 2019, the novel severe acute respiratory syndrome-associated coronavirus (SARS-CoV-2)¹ has infected over six million people and claimed more than 370,000 lives worldwide.² Unlike the 2003 SARS virus that had limited transmissibility before the symptom onset,³ the novel SARS-CoV-2 can be transmitted from pre-symptomatic and asymptomatic patients^{4–6} and cause sudden symptom exacerbation among mildly symptomatic patients, often leading to cytokine storm and acute respiratory distress syndrome (ARDS).^{7,8} The unprecedented scale of pandemic has forced many countries to adopt aggressive mitigating measures such as social distancing, closing schools and business,

and prohibiting large gatherings.^{9–11} Consequently, the epidemic in the United States has slowed down significantly, and many metropolitan areas have reached a turning point with reproduction numbers of one or below after 15 April 2020, as demonstrated in our previous study.¹²

Division of Epidemiology, Biostatistics and Environmental Health, School of Public Health, University of Memphis, Memphis, TN, USA

Corresponding author:

Xinhua Yu, Division of Epidemiology, Biostatistics and Environmental Health, School of Public Health, University of Memphis, 3825 Desoto Ave, Memphis, TN 38152, USA.

Email: xyu2@memphis.edu



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People aged 65 years or above were disproportionately affected by the pandemic, as about 80% of deaths occurred among this group (referred as elderly people in this report).¹³ Due to their physiologically weak immunity and high prevalence of comorbidities in which two-thirds of elderly people had two or more chronic conditions,¹⁴ elderly people might be more likely to have severe disease if infected by the virus. In addition, timely diagnosis was critical during the COVID-19 pandemic, as early diagnosis and treatment might allow early interventions to reduce the risk of developing ARDS. However, timely diagnosis and treatment might be impeded by myriads of health-care access barriers such as lack of transportation, difficulties in communicating with health-care providers, and the complexity of the health-care system.^{15,16} For example, in a Netherlands study, elderly breast cancer patients were more likely to be diagnosed with higher stage of cancer and less likely to receive surgical treatment.¹⁷ During the COVID-19 pandemic, many elderly patients living in New York, USA had prolonged stays in the intensive care units and one-fourth of them eventually died.¹⁸

Unfortunately, as history has shown, health inequalities might be exacerbated during the emerging epidemic.¹⁶ Awakened by this, many states started reporting the numbers of cases, hospitalizations, and deaths by age and racial/ethnicity groups, revealing a disproportionately heavier disease burden among vulnerable elderly populations and among African Americans and other minority groups.^{19,20} Health inequalities could be due to differences in socioeconomic status (SES). People with lower SES were more likely to have two or more chronic conditions than those with higher SES,^{21,22} and have limited access to health-care resources. Therefore, SES factors could play an important role in survival among elderly people during the COVID-19 pandemic.

One particular aspect of health service inequalities is related to the differences between urban and non-urban areas. Not only are health-care resources less sufficient in non-urban areas than urban areas, but also SES and age distributions are different between them.²³ Elderly living in non-urban areas were more likely to receive inadequate health care than elderly living in large urban areas.²⁴ For example, elderly colorectal cancer patients living rural areas were on average 18 days longer to receive a diagnosis than elderly living in urban areas.²⁵ Meanwhile, despite wide availability of maps representing the epidemic process, little was known about how geographic differences affected the health inequalities among elderly people living in large, medium, small metropolitan or rural areas. Existing reports and maps often focused on the description of the epidemic (e.g. websites driven by a geographic information system (GIS) system like that of Johns Hopkins University),² but none had carefully explored the inequalities underlying the reported case counts with appropriate epidemiological methods.

In this study, we aimed to examine urban and non-urban inequalities in health services use during the COVID-19 pandemic among elderly patients in Florida, USA from 2 March

to 27 May 2020. Since urban areas have more health-care resources than non-urban areas, and those living in non-urban areas are more likely to have lower SES, we hypothesized that those living in small metropolitan or rural areas might have lower rates of visiting an emergency department (ED), being hospitalized and higher mortality rates than those living in large or medium metropolitan areas.

Methods

Data sources

All lab-confirmed COVID-19 cases were listed online by the Florida Department of Health²⁰ and pre-processed.²⁶ The line list file included patient's county, age, gender, residency, case confirmation date, contact history, ever visited an ED, being hospitalized, and death status. However, no dates for ED visits, hospitalizations, or deaths were explicitly recorded in the file. Both the original list file and pre-processed data were publicly available.

Metropolitan status for each county was obtained from the National Center for Health Statistics.²⁷ Florida population data for 2018 were obtained from Florida health charts website.²⁸ We merged all these data sources by gender, age groups, and county. In this time series of COVID-19 cases in Florida, the first case was recorded on 2 March 2020. As of 27 May 2020, there were 53,285 confirmed COVID-19 cases. We excluded 23 patients who did not have age information, and additional 86 patients without county information, resulting in 53,176 COVID-19 cases of all age groups and 13,659 cases aged 65 years or above (referred as elderly people in this report) included in the analysis. The sample size is sufficiently large for this descriptive study.

Demographics and other characteristics

Patient's age was grouped into <25, 25–44, 45–64, 65–74, and 75+ years. However, except for Table 1 and Figure 1 which presented an overview of COVID-19 epidemic in Florida, our main analyses were restricted to patients aged 65 years or older, as the focus of this study was about health disparities among elderly people.

Metropolitan status of each county was classified as large metropolitan areas and their suburbs (one million or more people), medium metropolitan areas (250,000–one million), small metropolitan areas (50,000–250,000), and non-metro areas (counties with 50,000 or less people, broadly considered as rural areas in this report). The number of cases was listed in the appendix table by metropolitan status (Supplemental Appendix Table 3).

We also divided the whole epidemic into five periods: before 1 April 2020 and every 2 weeks thereafter (Table 1). After 1 April 2020, many control measures were enforced, including stay-at-home rule issued by the Florida state government on 3 April 2020. All models were adjusted for periods.

Table 1. Descriptive characteristics of COVID-19 cases diagnosed in Florida, USA as of 27 May 2020.

	Cases Number (column %)	Visited ED Number (rate %)	Hospitalized Number (rate %)	Deaths Number (rate %)
Total	53,176 (100.0%)	14,632 (27.5%)	10,056 (18.9%)	2446 (4.6%)
Age (years)				
<25	5273 (9.9%)	890 (16.9%)	230 (4.4%)	26 (0.5%)
25–44	16,369 (30.8%)	3458 (21.1%)	1321 (8.1%)	59 (0.4%)
45–64	17,875 (33.6%)	4846 (27.1%)	3043 (17.0%)	322 (1.8%)
65–74	6299 (11.8%)	2334 (37.1%)	2109 (33.5%)	524 (8.3%)
75+	7360 (13.8%)	3104 (42.2%)	3353 (45.6%)	1515 (20.6%)
Among age 65 years or older				
Total	13,659 (100.0%)	5438 (39.8%)	5462 (40.0%)	2039 (14.9%)
Gender				
Male	6481 (47.4%)	2809 (43.3%)	2773 (42.8%)	1105 (17.0%)
Female	7178 (52.6%)	2629 (36.6%)	2689 (37.5%)	934 (13.0%)
Metropolitan				
Large	9492 (69.5%)	3982 (42.0%)	3932 (41.4%)	1400 (14.7%)
Medium	3101 (22.7%)	1154 (37.2%)	1184 (38.2%)	472 (15.2%)
Small	615 (4.5%)	201 (32.7%)	216 (35.1%)	115 (18.7%)
Rural	451 (3.3%)	101 (22.4%)	130 (28.8%)	52 (11.5%)
Period				
Before 1 April 2020	1739 (12.7%)	994 (57.2%)	853 (49.1%)	332 (19.1%)
1 April to 14 April 2020	3705 (27.1%)	1774 (47.9%)	1674 (45.2%)	666 (18.0%)
15 April to 30 April 2020	3511 (25.7%)	1318 (37.5%)	1424 (40.6%)	637 (18.1%)
1 May to 14 May 2020	2578 (18.9%)	795 (30.8%)	902 (35.0%)	314 (12.2%)
15 May to 27 May 2020	2126 (15.6%)	557 (26.2%)	609 (28.6%)	90 (4.2%)

ED: emergency department.

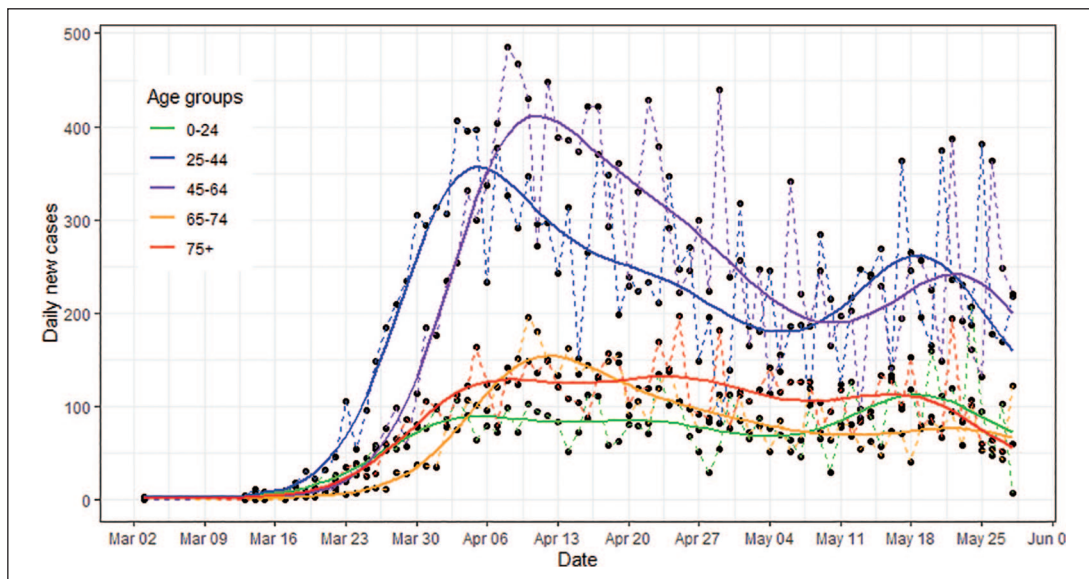


Figure 1. Fitted COVID-19 epidemic curves by age groups in Florida, USA, as of 27 May 2020.

Statistical analysis

In addition to descriptive statistics about the number of cases, COVID-19-associated ED visits, hospitalizations, and deaths, we calculated adjusted incident rates (per 1000

persons) for COVID-19 based on the Poisson regressions. The independent variable in the Poisson regressions was case counts by age and gender groups with age and gender-specific population in each county as the proper denominator. Therefore, the predicted rates from the above Poisson

regressions were the adjusted incidence by adjusting for age and pooling over all counties. In addition, using the line list file for individual COVID-19 cases, we employed logistic regressions to calculate probabilities (rates) of ED visits, hospitalizations, and deaths. The independent variable of the logistic regressions was the status (0/1) of ED visit, hospitalization, or death for each COVID-19 patient, adjusting for age, gender, period, and county. The adjusted rates were obtained from the predictive margins of the models. Furthermore, we predicted age-specific epidemic curves from semi-parametric generalized additive models with smoothed time terms, assuming daily new cases follow a negative binomial distribution. We also mapped the adjusted hospitalization rates (per 100 cases) for each county based on a Poisson model.

SAS 9.4 (SAS Inc, Cary, NC, USA), Stata 16.1 (Stata Inc, College Station, TX, USA), and R *mgcv* package²⁹ were used in the analysis. Although we set the large metropolitan area as the reference group for most of our comparisons, the Bonferroni adjustment was also used to account for multiple comparisons, assuming a significance level of $p < 0.01$ for all comparisons. Data and codes are available online: <https://github.com/xinhuayu/urbanruralFL>.

Results

Table 1 presented an overview of COVID-19 epidemic in Florida as of 27 May 2020. Of 53,176 confirmed cases, 27.5% of cases had visited ED, 18.9% were hospitalized, and 4.6% died. Majority of cases were in metropolitan counties (Supplemental Appendix Table 3). Although cases aged 65 years or older accounted for only 25.6% of total cases, they accounted for 54.3% of hospitalizations and 83.4% of deaths. They were two to three times more likely to be hospitalized, and five to ten times more likely to die than people aged 45–64 years (Table 1).

Among those 13,659 elderly patients, about 40% of them visited an ED and 40% of them were hospitalized. About 14.9% of them died (Table 1). Elderly men were slightly more likely to visit an ED, be hospitalized, and die than elderly women. About 7.8% of elderly patients lived in small metropolitan or rural areas. They had lower unadjusted rates of ED visits and hospitalizations compared with those living in large or medium metropolitan areas. Those who were diagnosed before 1 April were more likely to visit an ED, be hospitalized, or die than those who were diagnosed after 1 April, possibly because more mildly symptomatic patients were detected in late periods. The lower rates of ED visits, hospitalizations, and deaths during the last period (after 15 May) were more likely due to reporting delays.

Figure 1 presented the epidemic curves by age groups. The epidemic among people aged 25–44 years seemed to lead the epidemic in the whole population, followed by those aged 45–64 years and those aged 65–74 years. These groups had experienced two peaks: one major peak around 5–10

April, and a small one around 15–20 May. However, the daily new cases among people aged 75 years or above remained stable from around 1 April to around 15 May. Similar patterns existed in the epidemic curves by metropolitan statuses among elderly people (Supplemental Appendix Figure 1).

The adjusted incident rates of COVID-19 and adjusted rates of ED visits, hospitalizations, and deaths among COVID-19 patients were presented in Figure 2(a)–(d) (details in Supplemental Appendix Tables 1 and 2). Overall, the differences in adjusted incident rates between elderly men and women were small, while elderly men were more likely to have an ED visit ($p < 0.01$ for men vs women aged 75 years or above), be hospitalized, or die with COVID-19 than elderly women of the same age group and living in the same areas, although many comparisons were not statistically significant after the Bonferroni adjustment.

Furthermore, those living in small metropolitan areas had lower incident rates than those living in large or medium metropolitan areas (Figure 2(a) and Supplemental Appendix Table 1). For example, for men aged 65–74 years living in small metropolitan areas, the adjusted incidence was about 43% lower than that of large metropolitan areas (1.56 vs 2.82 per 1000 persons; rate ratio (RR): 0.57; 95% confidence interval (CI): (0.33–0.98), $p = 0.04$). Similar reduction was observed among women aged 65–74 years (1.18 vs 2.18 per 1000 persons comparing small metropolitan with large metropolitan areas; RR: 0.53 (0.32–0.89), $p = 0.02$). However, elderly people living in rural areas tended to have higher incidence of COVID-19 than those living in large metropolitan areas. Particularly, women aged 75 years or above living in rural areas had more than double of incidence than those living in large metropolitan areas (6.68 vs 3.10 per 1000 persons; RR: 2.23 (1.21–4.12), $p = 0.01$).

Figure 2(b)–(d) presented adjusted rates of ED visits, hospitalizations, and deaths by metropolitan statuses for each age and gender group. There were significant decreasing trends of ED visits across metropolitan statuses (all p for trend < 0.01 , Figure 2(b) and Supplemental Appendix Table 2). For example, male patients aged 65–74 years living in rural areas had 53% lower rate of ED visits than those living in large metropolitan areas (22% vs 41%, odds ratio (OR): 0.47 (0.29–0.75), $p = 0.002$). Female patients aged 75 years or above living in rural areas had 79% lower rate of ED visits than those living in large metropolitan areas (13% vs 43%, OR: 0.21 (0.13–0.34), $p < 0.001$). Similarly, those living in small metropolitan also had lower rates of ED visits than those living in large metropolitan areas.

Overall, there were decreasing trends of hospitalization rates across metropolitan statuses, but most evident among female patients aged 75 years or above (Figure 2(c) and Supplemental Appendix Table 2). Female patients aged 75 years or above living in small metropolitan or rural areas had 53% and 63% lower rates of hospitalizations than those living in large metropolitan areas (29% vs 46% for both

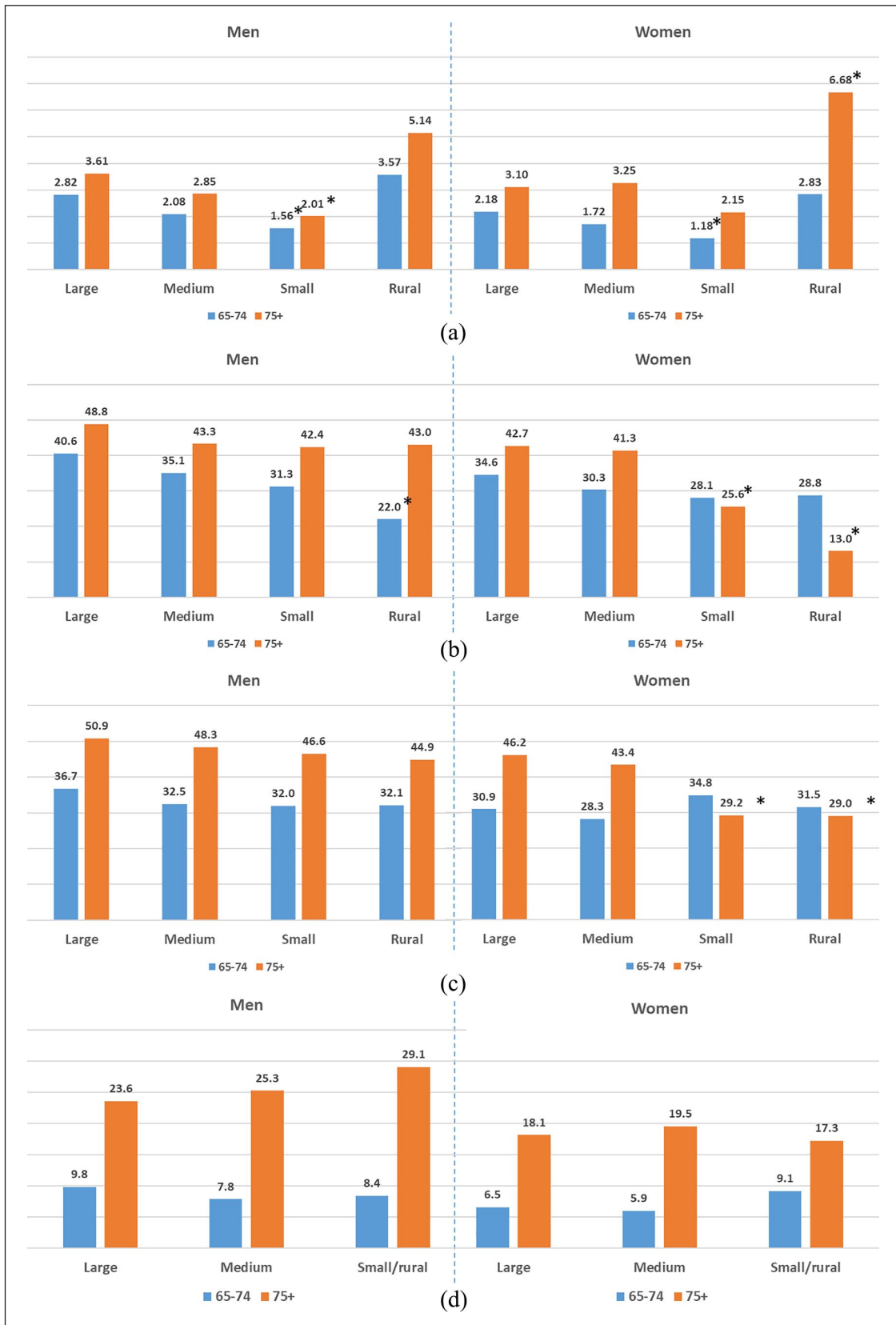


Figure 2. Adjusted incidence (per 1000 persons) (a), and rates (per 100 cases) of emergency department visits (b), hospitalizations (c), and deaths (d) among elderly people with COVID-19, Florida, USA as of 27 May 2020.
* $p < 0.01$ compared with the large metropolitan areas, after the Bonferroni adjustment.

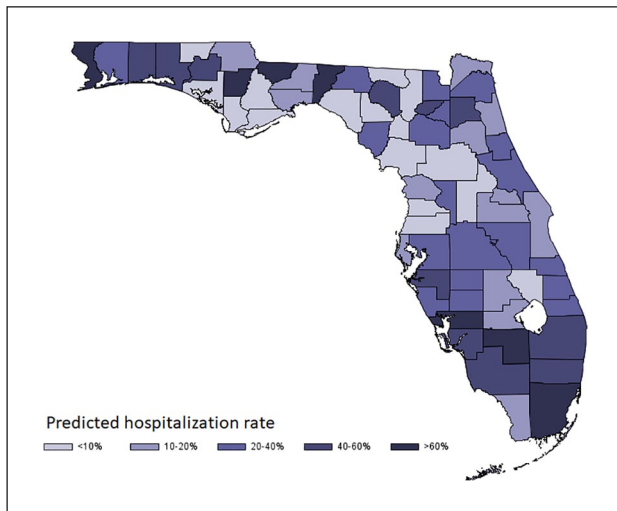


Figure 3. Choropleth map of hospitalization rates among people aged 65 years or older by counties, Florida, USA, as of 27 May 2020.

comparisons, OR: 0.47 (0.34–0.66) and 0.37 (0.25–0.54) for small metropolitan and rural areas, respectively; both $p < 0.001$).

Due to small number of deaths in small metropolitan and rural areas, we combined them in the analysis (Figure 2(d) and Supplemental Appendix Table 2). There was no difference in death rates across metropolitan statuses.

The adjusted hospitalization rates were mapped by counties (Figure 3). In addition to Miami-Dade County (right southeast corner), there were pockets of small metropolitan or non-metro counties in the north or middle of Florida that had 40%–60% or 60+ % hospitalization rates (darker color).

Discussion

This was the first study that documented significant health inequalities between large urban areas and small metropolitan or rural areas during the COVID-19 pandemic. In Florida, USA, elderly people living in small metropolitan areas had lower incidence of COVID-19, while those living in rural areas had higher incidence than those living in large or medium metropolitan areas. However, there were decreasing trends of ED visits and hospitalizations across metropolitan statuses. Particularly, the rates of ED visits and hospitalizations were significantly lower among female patients aged 75 years or above living in small metropolitan or rural areas. However, the differences in COVID-19-related deaths were less evident between urban and non-urban areas. Many other factors could affect the risk of deaths due to COVID-19, and regional characteristics might play a less important role in mortality.

The reasons for lower incident COVID-19 rates in small metropolitan areas but higher incident rates in rural areas were complicated. The dispersed residence in small metropolitan and rural areas may deter the virus transmission, leading to relatively lower incident rates of COVID-19.

However, there might not be enough detection kits available in these areas, resulting in artificially lower incident rates compared with large metropolitan areas. In addition, people living in rural areas might be more likely to rely on community centers and churches for social events. Regular gathering in community centers or churches might cause outbreaks of COVID-19, leading to abrupt increases of cases.

Furthermore, our findings confirmed deficiencies in providing health care to elderly people living outside of large or medium metropolitan areas.^{30,31} Health-care facilities in the United States were mostly concentrated in large cities. Elderly people living in small metropolitan or rural areas were known for lacking adequate health care.³² In the time of emerging pandemic such as COVID-19, these problems may be aggravated when health-care resources were under pressure. Many small metropolitan or rural hospitals were not equipped to manage infectious patients. Patients with mild symptoms might be triaged to self-care at home, without being diagnosed and lab confirmed. For elderly people, this was not ideal, as the respiratory symptoms might exacerbate suddenly.⁷ Many of these severe cases were likely transferred to hospitals in larger cities, often enduring all kinds of troubles during the process.

Although the differences in the incident rates of COVID-19 between elderly men and women were small, there were gender differences in the rates of ED visits, hospitalizations, and deaths among patients aged 75 years or above living in small metropolitan or rural areas. This required careful explanations. It was unclear whether this was due to differences in disease severity, symptom tolerance, health-care seeking behavior, or availability and accessibility to health care. Women were known to have lower tolerance of pain,³³ but this might not be applicable to infectious diseases. One possibility is self-medication among elderly people, especially among small metropolitan and rural areas where health-care resources are limited.^{34,35} Over-the-counter (OTC) medications for relieving respiratory symptoms (e.g. coughing and fever) are readily available in most US households. However, it was unclear where elderly people might rely on OTC to mitigating respiratory symptoms during the COVID-19 pandemic.

Although our knowledge of COVID-19 was growing rapidly, the treatment outcomes were still unsatisfactory. Treating ARDS was still a major challenge, often leading to a mortality rate of 50% among those with ARDS.^{7,18} Many elderly patients, especially those with underlying conditions such as cardiovascular diseases and diabetes, often had more severe diseases than those who were young and healthy. Therefore, a coordinated public health system, together with timely virus detection, case isolation, symptom monitoring, and active contact tracing, were more important to curb the epidemic. Small metropolitan and rural areas should not be overlooked in building this system.

This study had some limitations. First, not all patient's information was publicly released due to privacy

concerns. There were no explicit and accurate dates of symptom onset, clinic or ED visits, hospitalizations, and deaths for each patient. Therefore, we were only able to use logistic regressions to model the cumulative incidence of the ED visits, hospitalizations, and deaths among those diagnosed with COVID-19. In addition, there was no information such as race and ethnicity, income, and education levels in the file, hindering our ability to fully explore the roots of disparities¹⁶ and precluding us from examining causalities of these health service inequalities. However, this problem was not unique to Florida. Many other states released aggregated data only. To some extent, we had more than enough data that were useful to paint a broad picture, but no good data to help us understand the drivers of epidemic process and examine health disparities behind the case counts.

Second, this study was based on the existing data on the confirmed and reported cases, thus missed people who were infected with the virus but not reported (possibly asymptomatic or mildly symptomatic). This may bias our results. Although elderly patients might be more likely to have symptoms if infected by the virus, we would nevertheless miss many asymptomatic or mildly symptomatic patients who did not seek care thus were not detected. We did not know whether the proportion of asymptomatic patients differed between large metropolitan areas and small metropolitan or no-metro areas. In addition, the detection kits were not readily available to health providers, especially at the early stage of epidemic and in small metropolitan and rural areas. Therefore, patients living in small metropolitan or rural areas might be more likely to employ self-care or be triaged without diagnosis. We might underestimate the case incidences and overestimate the rates of ED visits and hospitalizations among those living in small metropolitan or rural areas. The true health inequalities might be worse than our observed differences.

Third, this study only used Florida data because of the availability of individual cases. Although Florida has a larger percent of elderly population than many other US states, we should still be cautious to generalize our findings to other regions. In addition to the differences in population structure, other differences due to SES, physical environment (e.g. temperature, humidity, and altitude), and the scale of interventions and societal compliance to the interventions may all influence health inequalities during the epidemic process.

Finally, the COVID-19 pandemic was still evolving. Although our previous research indicated that the epidemic development such as effective reproduction numbers had reached plateau since later April in the 30 US largest metropolitan areas,¹² there would still be a lot of new cases to come every day, as the instantaneous reproduction numbers remained around one in many US metropolitan areas right till 27 May 2020. The patterns of hospitalizations and deaths by different age, gender, and regions would likely be more evident at the end of epidemic. Furthermore, given that much was still unknown regarding the treatments and consequences

of COVID-19, elderly people might be impacted more profoundly by the epidemic and health inequalities due to possible long last disease consequences. In addition, given that this study is based on publicly available data of the whole epidemic process, sample size calculation was not performed. However, the statistical power of detecting differences between the groups may be hampered by the smaller numbers in certain groups. For example, the small number of deaths in rural counties lead to no statistical differences between groups, although some crude differences existed.

There were some unique strengths in our study. To our knowledge, this was the first study using individual patient information to examine urban and non-urban inequalities in the current COVID-19 pandemic. Health inequality issue was often neglected in the time of emerging epidemic, which was the reason for recent urgent calls to tabulate cases and deaths by age, gender, and race/ethnicities. Our research pointed to another dimension that should also be incorporated in epidemic reports. Furthermore, unlike common descriptive reports that focused on the numbers of new cases, hospitalizations, and deaths, we employed analytical methods to uncover hidden health inequalities that were not evident in the aggregated tables. For example, comparing crude rates in Table 1 and adjusted rates in Supplemental Appendix Table 2, only after careful adjustments did health inequalities emerge. Therefore, our study called for more good data, more transparent reporting, and more appropriate analyses.

Conclusion

In summary, profound health inequalities between urban and non-urban areas existed in the time of emerging pandemic like COVID-19. In Florida, USA, elderly people living in small metropolitan areas had lower incident rates, while elderly people living in rural areas had higher incident rates of COVID-19 than those living in large metropolitan areas. However, elderly patients living in small metropolitan or rural areas were less likely to have ED visits and hospitalizations than those living in large metropolitan areas, especially among female patients aged 75 years or above living in these areas. Therefore, more supports and more resources should be granted to health-care providers who serve the vulnerable populations in small metropolitan and rural areas.

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Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

This study was deemed exempt from ethical review, as it used publicly available data that have no individually identifiable information, and therefore, the analysis would not involve human subjects. Therefore, there is no need for the Institutional Review Board (IRB) review.

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ORCID iD

Xinhua Yu  <https://orcid.org/0000-0003-2392-3740>

Supplemental material

Supplemental material for this article is available online.

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