Socioeconomic Disparities in Community Mobility Reduction and COVID-19 Growth

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Abstract

Objective: To examine differences in community mobility reduction and severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) outcomes across counties with differing levels of socioeconomic disadvantage.

Methods: The sample included counties in the United States with at least one SARS-CoV-2 case between April 1 and May 15, 2020. Outcomes were growth in SARS-CoV-2 cases, SARS-CoV-2–related deaths, and mobility reduction across three settings: retail/recreation, grocery/pharmacy, and workplace. The main explanatory variable was the social deprivation index (SDI), a composite socioeconomic disadvantage measure.

Results: Adjusted differences in outcomes between low-, medium-, and high-SDI counties (defined by tertile) were calculated using linear regression with state-fixed effects. Workplace mobility reduction was 1.75 (95% CI, -2.36 to -1.14; $P<.001$) and 3.48 percentage points (95% CI, -4.21 to -2.75; $P<.001$) lower for medium- and high-SDI counties relative to low-SDI counties, respectively. Mobility reductions in the other settings were also significantly lower for higher-SDI counties. In analyses adjusted for SARS-CoV-2 prevalence on April 1, medium- and high-SDI counties had 1.39 (95% CI, 0.85 to 1.93; $P<.001$) and 2.56 (95% CI, 1.77 to 3.34; $P<.001$) more SARS-CoV-2 cases/1000 population on May 15 compared with low-SDI counties, respectively. Deaths per capita were also significantly higher for higher-SDI counties.

Conclusion: Counties with higher social deprivation scores experienced greater growth in SARS-CoV-2 cases and deaths, but reduced mobility at lower rates. These findings are consistent with evidence demonstrating that economically disadvantaged communities have been disproportionately impacted by the coronavirus disease 2019 pandemic. Efforts to socially distance may be more burdensome for these communities, potentially exacerbating disparities in SARS-CoV-2–related outcomes.

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To date, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has infected more than 32 million individuals resulting in approximately 986,000 deaths worldwide. Approximately 22% of SARS-CoV-2 reported cases and 21% of deaths have occurred in the United States.[1] There is growing evidence that economically disadvantaged communities have been disproportionately impacted by the coronavirus disease 2019 (COVID-19) pandemic, shown through their higher SARS-CoV-2 incidence and case fatality rates.[2,3] To reduce the impact of COVID-19, the Centers for Disease Control and Prevention and the World Health Organization have encouraged the adoption of social distancing, which has been mandated by state and local governments in various forms since March 2020. However, efforts to implement social distancing may be more burdensome for economically disadvantaged communities, potentially exacerbating disparities in SARS-CoV-2 spread and related outcomes.[4] As such, this study's objective was to examine the relationships between

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socioeconomic disadvantage, mobility levels, growth in SARS-CoV-2 cases, and SARS-CoV-2−related deaths.

METHODS

Study Sample

The unit of analysis was counties in the United States. All counties with at least one SARS-CoV-2 case by May 15, 2020 (n=2833), were included. Counties with data missing on any measure were excluded, yielding a final sample of 2664 counties. Institutional Review Board oversight was not required as all data are aggregated and publically available.

Data Sources

SARS-CoV-2 Cases and Deaths. Data on cumulative SARS-CoV-2 cases and related deaths reported on April 1, 2020 (baseline level for this study), and May 15, 2020, were obtained from a repository maintained by the Johns Hopkins University Center of Systems Science and Engineering.[1] The Center of Systems Science and Engineering collects SARS-CoV-2 case and death data reported by state and county departments of public health in real time. Data are combined into a publicly available, county-level dataset containing the cumulative number of SARS-CoV-2 cases and deaths on each day since January 2020 to the present date.

Community Mobility. Data on community mobility levels were obtained from Google COVID-19 Mobility Reports.[5] The Mobility Reports include percent changes in the frequency of individual visits to different types of settings relative to a baseline period before COVID-19 (the period between January 3 and February 6, 2020), based on aggregated mobile device user data. The settings tracked include: workplace, grocery and pharmacy, retail and recreation, parks, transit stations, and residences. For this study, mobility changes in the park, transit station, and residential settings were not examined due to a high level of missing data. Missingness occurred when there was an insufficient amount of data to ensure user anonymity, but does not necessarily imply low mobility levels.

Other Data Sources. The Robert Graham Center provides a composite measure of socioeconomic disadvantage at the county level based on socioeconomic characteristics reported in the American Community Survey, discussed below.[6] The Area Health Resources File (AHRF) is a publicly available, county-level dataset maintained by the Health Resources and Services Administration.[7] The AHRF includes combined data on economic characteristics, health care supply, population health, and other population characteristics from multiple data sources such as the Census and Medicare. For this study, the AHRF was the source of population size, population density, demographic characteristics, and level of urbanization.

Main Outcomes and Measures

The study outcomes were growth in SARS-CoV-2 prevalence, SARS-CoV-2−related deaths per capita, and percent reduction in community mobility during the month of April 2020 in the workplace, grocery and pharmacy, and retail and recreation settings. The main explanatory variable for this study was the social deprivation index (SDI).[6] The SDI is a composite county-level measure of seven socioeconomic characteristics. These include: percent of adults without a high school degree, percent of households with a single parent, percent living in overcrowded housing, percent living in rental units, percent of households without a car, the unemployment rate, and the poverty rate. The SDI ranges from 1 to 100, with higher values representing greater deprivation. To facilitate the interpretability of analyses, counties were divided according to tertile of SDI (based on the 33rd and 67th percentiles) and classified as having low-, medium-, and high-SDI levels.

Statistical Analysis

We examined the relationships between SARS-CoV-2 cases and deaths per capita, and community mobility reduction with SDI graphically using locally weighted

TABLE 1. Characteristics of Counties by Social Deprivation Index Level[a,b]

Characteristic, mean (SD) or n (%)	SDI level Low (n=837)	Medium (n=915)	High (n=912)
Population size (1000s)	84.9 (167.2)	103.0 (216.7)	148.6 (512.1)
Population density[c]	163.1 (360.8)	173.2 (431.2)	259.9 (1048.3)
CBSA			
Metropolitan[d]	394 (47.1)	391 (42.7)	339 (37.2)
Micropolitan[d]	152 (18.2)	208 (22.7)	259 (28.4)
Non-CBSA/rural[d]	291 (34.7)	316 (34.5)	314 (34.3)
Below poverty line	10.8 (2.8)	16.3 (3.4)	22.7 (5.3)
Without high school degree	9.2 (2.8)	14.3 (1.6)	20.0 (5.9)
Households with single parent	13.3 (2.3)	15.7 (2.6)	20.2 (3.9)
Households without car	4.7 (1.5)	6.3 (2.2)	8.3 (3.1)
Renters	24.2 (5.1)	28.3 (6.7)	32.7 (7.7)
Living in overcrowded housing	1.5 (0.1)	2.2 (1.3)	3.3 (2.2)
Unemployed	5.4 (1.9)	7.3 (2.2)	8.3 (2.7)
Black	2.7 (4.5)	5.8 (7.7)	19.4 (19.5)
Hispanic	4.9 (4.8)	8.3 (10.8)	12.9 (18.7)
Mobility reduction (% from baseline)			
Retail and recreation	39.7 (13.2)	34.2 (12.3)	29.4 (11.6)
Workplace	38.8 (8.7)	37.5 (7.7)	34.9 (7.4)
Grocery and pharmacy	10.1 (13.5)	6.2 (13.1)	2.6 (13.2)
Cumulative cases per 1000 population, April 1	0.25 (0.67)	0.21 (0.60)	0.24 (0.49)
Cumulative cases per 1000 population, May 15	1.87 (2.94)	2.29 (6.94)	3.46 (6.21)
Cumulative deaths per 1000 population, May 15	0.09 (0.19)	0.09 (0.18)	0.15 (0.29)

[a]CBSA = core-based statistical area; SDI = social deprivation index.
[b]County SDI ranges from 1 to 100 (higher = more deprived) and was classified as low (1 to 23), medium (24 to 53), and high (54 to 100) based off of tertile rank. Social deprivation index tertile was calculated using all 3143 US counties. However, because the analytic sample does not include all counties (see Methods section for details), there are differences in the number of counties in each stratum.
[c]Population density is equal to the number of persons per square land mile.
[d]Metropolitan, micropolitan, and non−core based statistical area/rural designations were developed by the Office of Management and Budget. Metropolitan counties are associated with an urbanized area containing at least 50,000 individuals; micropolitan counties are associated with an urban cluster that includes 10,000 to 50,000 individuals; rural counties are not associated with an urbanized area or cluster.

scatter plot smoothing (LOESS). To show growth in SARS-CoV-2 cases, we compared cumulative cases reported on May 15 versus April 1, 2020, separately for counties with low-, average-, and high-SDI levels. We also examined the relationship between mobility reduction and SDI conditional upon cases per capita in April because the baseline outbreak level may influence subsequent mobility reduction.

We then estimated adjusted differences in outcomes between low-, average-, and high-SDI counties using linear regression with state-fixed effects. Covariates included were SARS-CoV-2 cases per capita on April 1, 2020 (which effectively allows the model to estimate case growth), population size and density, and rural-urban classification, based on whether a county was located in a metropolitan, micropolitan, or non−core based (rural) statistical area as delineated by the US Office of Management and Budget. Because the spread pattern of SARS-CoV-2 is likely to differ between urban and rural areas, in sensitivity analyses we stratified regression models according to level of urbanization.

Robust standard errors were used in all models. Data were analyzed using Stata MP 16.0 (StataCorp, College Station, TX). Null

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hypotheses were tested assuming a two-sided type I error probability of .05.

RESULTS

The characteristics of counties with low-, medium-, and high-SDI levels are listed in Table 1. Counties with higher SDI levels were larger and more densely populated, and had higher percentages of Black and Hispanic residents. The distribution of SDI component measures and the five study outcomes are also shown.

The relationship between mobility reduction and baseline SARS-CoV-2 prevalence on April 1, 2020, stratified by county SDI is shown in Figure 1. Counties more impacted by COVID-19 reduced mobility at higher rates in all three settings (retail and recreation, grocery and pharmacy, and workplace). However, in every setting and for any given baseline outbreak level, counties with higher SDI had lower mobility reductions. Figure 2A shows the relationship between SARS-CoV-2 prevalence on May 15, 2020, and baseline outbreak level stratified by county SDI. Figure 2B shows the relationship between SARS-CoV-2—related deaths and baseline outbreak level. Counties that were more impacted by COVID-19 in April 2020 had on average more SARS-CoV-2 cases and deaths by May 2020. However, for any baseline outbreak level, SARS-CoV-2 cases and deaths in May 2020 were greater for counties with higher SDI.

The adjusted association between county SDI level and mobility reduction outcome is shown in Table 2. The amount of workplace mobility reduction was 3.48 percentage points (95% CI, -4.21 to -2.75; $P<.001$) lower for high-SDI counties relative to low-SDI counties, and 1.75 points lower (95% CI, -2.36 to -1.14; $P<.001$) for medium-SDI counties. The amount of mobility reduction in retail and recreation was 6.15 percentage

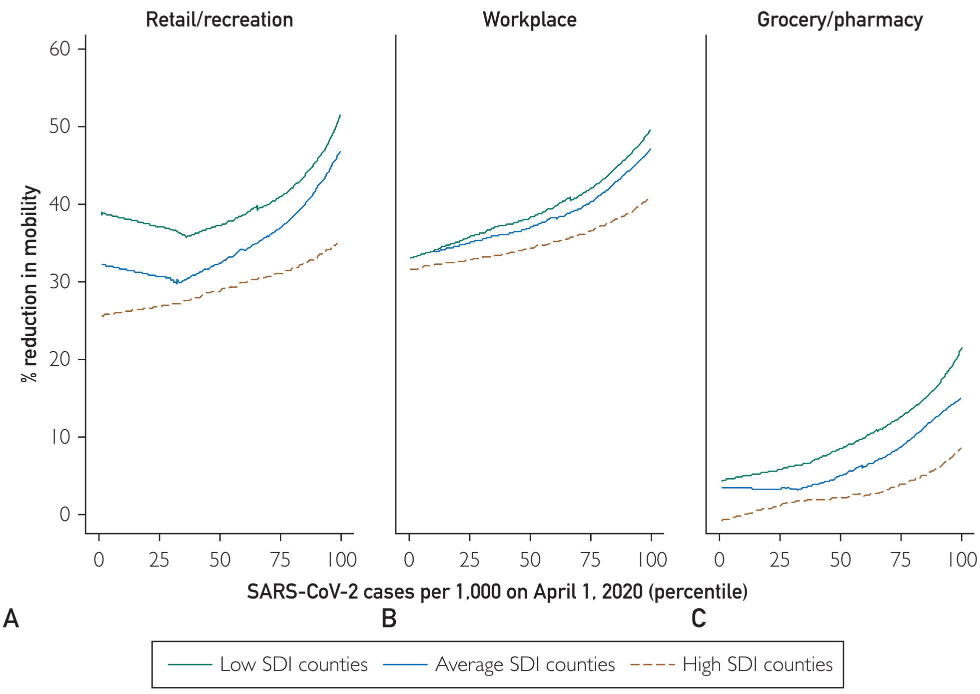

FIGURE 1. Mobility reduction in April by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) prevalence on April 1, 2020, for counties with low, medium, and high social deprivation index levels. A, Retail/recreation. B, Workplace. C, Grocery/pharmacy. Plots are drawn using locally weighted smoothing. County social deprivation index (SDI) level was classified as low, medium, and high based off of tertile rank.

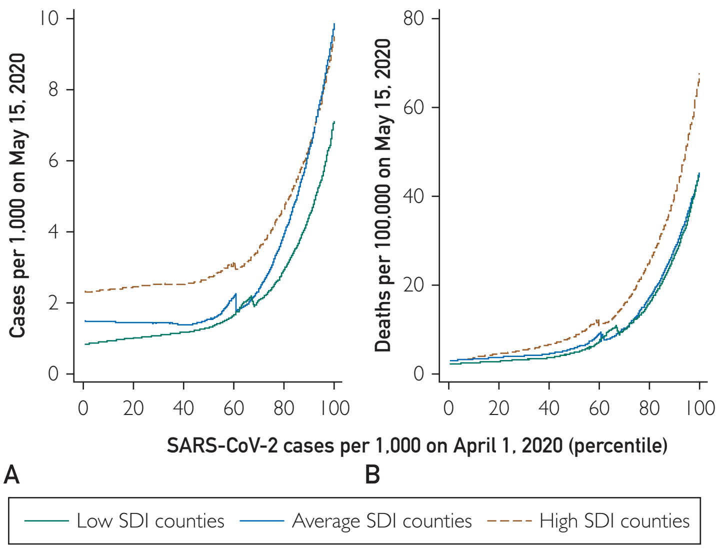

FIGURE 2. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) prevalence and deaths on May 15, 2020, by SARS-CoV-2 prevalence on April 1, 2020, for counties with low, medium, and high social deprivation index levels. A, Cases per 1000 persons, May 15, 2020. B, Deaths per 100,000 on May 15, 2020. Plots are drawn using locally weighted scatter plot smoothing smoothing. County social deprivation index (SDI) level was classified as low, medium, and high based off of tertile rank.

points (95% CI, -7.43 to -4.87; *P*<.001) lower for high-SDI counties relative to low-SDI counties, and 3.24 points lower (95% CI, -4.41 to -2.07; *P*<.001) for medium-SDI counties. The amount of mobility reduction in the grocery and pharmacy settings was 4.68 percentage points (95% CI, -6.10 to -3.26; *P*<.001) lower for high-SDI counties relative to low-SDI counties, and 2.51 points lower (95% CI, -3.77 to -1.25; *P*<.001) for medium-SDI counties. In analyses stratified by metropolitan, micropolitan, and rural location (Supplemental Table, available online at http://www.mayoclinicproceedings.org), higher SDI level was also associated with lower mobility reductions in most settings.

The adjusted associations between county SDI level and SARS-CoV-2–related outcomes are also listed in Table 2. The adjusted difference in SARS-CoV-2 cases per 1000 persons reported in May 2020 between high- and low-SDI counties was 2.56 (95% CI, 1.77 to 3.34; *P*<.001), and the difference in deaths per 100,000 was 5.09 (95% CI, 3.25 to 6.94; *P*<.001). The adjusted difference in SARS-CoV-2 cases per 1000 persons between medium- and low-SDI counties was 1.39 (95% CI, 0.85 to 1.93; *P*<.001), and the difference in deaths per 100,000 was 1.63 (95% CI, 0.20to 3.06; *P*=.03). In analyses stratified by metropolitan, micropolitan, and rural location (Supplemental Table), higher SDI level was also associated with more SARS-CoV-2 cases and related deaths in May 2020. However, in rural areas, there was no association between SDI and SARS-CoV-2–related deaths.

DISCUSSION

This study shows a disparity in SARS-CoV-2–related outcomes between US counties with high and low levels of economic disadvantage. Growth in SARS-CoV-2 cases and related deaths was higher for counties with higher SDI levels. Compared with low-SDI counties, those with higher SDI levels had between one and three additional SARS-CoV-2 cases per 1000 individuals and between two and five additional deaths per 100,000. At the same time, rates of community mobility did not decline as much for higher-SDI counties. Compared with low-SDI counties, levels of mobility reduction were from 2 to 6 percentage points lower for higher-SDI counties.

Our results suggest that economically disadvantaged communities are most in need of SARS-CoV-2 testing, contact tracing, and social distancing. Social distancing has proven to be an effective tool for reducing SARS-CoV-2 spread.[8,9] However, for several reasons, vulnerable communities may not be as able to socially distance given that mobility reductions were lowest among high-SDI counties. For example, the proportion of intergenerational households may be greater in high-SDI counties, and residents may be more frequently employed in essential service positions (eg, grocery) or less able to access unemployment benefits. If individuals are unable to stay at home, additional policy efforts will be needed to

TABLE 2. Regression of Outcomes Onto Social Deprivation Index and Covariates[a]

	Mobility reduction outcomes						SARS-CoV-2—related outcomes			
	Retail/Recreation		Grocery/Pharmacy		Work Place		Cases/1,000		Deaths/100,000	
Variable	β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*	β (95% CI)	*P*
SDI										
Low (referent)										
Medium	-3.24 (-4.41 to -2.07)	<.001	-2.51 (-3.77 to -1.25)	<.001	-1.75 (-2.36 to -1.14)	<.001	1.39 (0.85 to 1.93)	<.001	1.63 (0.20 to 3.06)	.03
High	-6.15 (-7.43 to -4.87)	<.001	-4.68 (-6.10 to -3.26)	<.001	-3.48 (-4.21 to -2.75)	<.001	2.56 (1.77 to 3.34)	<.001	5.09 (3.25 to 6.94)	<.001
Cases/population on April 1, 2020	3.50 (2.54 to 4.46)	<.001	2.84 (1.76 to 3.92)	<.001	2.12 (1.45 to 2.79)	<.001	3.19 (2.59 to 3.78)	<.001	16.86 (10.04 to 23.68)	<.001
Population density[b]	1.97 (1.21 to 2.73)	<.001	1.36 (0.76 to 1.97)	<.001	2.07 (1.27 to 2.88)	<.001	0.35 (0.06 to 0.64)	.017	2.63 (0.32 to 4.96)	.03
Urbanization[c]										
Rural (referent)										
Metropolitan	-1.17 (-2.30 to -0.04)	.04	4.70 (3.42 to 5.98)	<.001	5.46 (4.88 to 6.03)	<.001	0.55 (0.02 to 1.08)	.044	0.55 (-1.23 to 2.33)	.55
Micropolitan	-3.18 (-4.37 to -1.99)	<.001	4.35 (2.98 to 5.71)	<.001	1.84 (1.28 to 2.40)	<.001	0.24 (-0.20 to 0.68)	.28	-0.87 (-2.65 to 0.92)	.34
Population (per 100,000)	0.24 (0.05 to 0.42)	.01	0.27 (0.09 to 0.45)	.004	0.32 (0.06 to 0.56)	.02	-0.01 (-0.05 to 0.030)	.69	0.17 (-0.06 to 0.39)	.14

[a]SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2; SDI = Social deprivation index (County SDI level was classified as low, medium, and high, with high indicating the most deprived based off of tertile rank. Point estimates are calculated from linear regression models with state fixed effects. Robust standard errors were used.).

[b]Population density is equal to thousands of persons per square land mile.

[c]Metropolitan, micropolitan, and non—core based statistical area/rural designations were developed by the Office of Management and Budget. Metropolitan counties are associated with an urbanized area containing at least 50,000 individuals; micropolitan counties are associated with an urban cluster that includes 10,000 to 50,000 individuals; rural counties are not associated with an urbanized area or cluster.

ensure the safety of economically disadvantaged communities.

Study Limitations

This study has several limitations. First, there are several weaknesses of the study data. For instance, the SDI measure was developed using 2011 to 2015 American Community Survey measures, and a more contemporary version is not yet available. The Johns Hopkins SARS-CoV-2 data are widely used and are consistently reported across counties. However, Johns Hopkins does not have control over the quality of the data submitted by state and local public health departments. The mobility data are derived from smartphone users with Google location services turned on. Although approximately half of smartphones rely on Google Android software, individuals using other operating systems and individuals without smartphones are excluded from these measures. Mobility and SARS-CoV-2 data may also be measured differentially by SDI level. For example, potentially lower SARS-CoV-2 testing in high-SDI counties may attenuate estimated differences in outcomes between low-SDI counties.

Second, we did not examine the contribution of specific socioeconomic factors to differences in outcomes because SDI is an aggregate of many of these factors. Third, due to the study's observational design, the estimated associations between SDI and outcomes are subject to residual confounding. Fourth, we cannot identify a mechanism for why mobility reductions were lower in high-SDI counties. While we hypothesize that this was due to lower ability to stay at home, willingness to socially distance may also play a role. Fifth, we do not directly estimate the contribution of lower mobility reduction to greater SARS-CoV-2 spread in high-SDI counties because with these aggregate, observational data we cannot distinguish mobility reductions leading to lower SARS-CoV-2 prevalence from reductions occurring in response to increased prevalence.

CONCLUSION

US counties with higher SDI scores experienced greater growth in the number of SARS-CoV-2 cases and related deaths, but reduced mobility at lower rates. Containing COVID-19 in disadvantaged communities may require public health interventions beyond social distancing.

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SUPPLEMENTAL ONLINE MATERIAL

Supplemental material can be found online at http://www.mayoclinicproceedings.org. Supplemental material attached to journal articles has not been edited, and the authors take responsibility for the accuracy of all data.

Abbreviations and Acronyms: **COVID-19** = coronavirus disease 2019; **SDI** = social deprivation index; **SARS-CoV-2** = severe acute respiratory syndrome coronavirus

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