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Community-Level Factors Associated With Racial And Ethnic Disparities In COVID-19 Rates In Massachusetts

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ABSTRACT Massachusetts has one of the highest cumulative incidence rates of coronavirus disease 2019 (COVID-19) cases in the US. Understanding which specific demographic, economic, and occupational factors have contributed to disparities in COVID-19 incidence rates across the state is critical to informing public health strategies. We performed a cross-sectional study of 351 Massachusetts cities and towns from January 1 to May 6, 2020, and found that a 10-percentage-point increase in the Black non-Latino population was associated with an increase of 312.3 COVID-19 cases per 100,000 population, whereas a 10-percentage-point increase in the Latino population was associated with an increase of 258.2 cases per 100,000. Independent predictors of higher COVID-19 rates included the proportion of foreign-born noncitizens living in a community, mean household size, and share of food service workers. After adjustment for these variables, the association between the Latino population and COVID-19 rates was attenuated. In contrast, the association between the Black population and COVID-19 rates persisted but may be explained by other systemic inequities. Public health and policy efforts that improve care for foreign-born noncitizens, address crowded housing, and protect food service workers may help mitigate the spread of COVID-19 among minority communities.

As of mid-2020 the US was the epicenter of the global coronavirus disease 2019 (COVID-19) pandemic. Massachusetts had among the highest case and death rates in the country for much of the spring,[1] and early reports suggest that Black and Latino populations are being disproportionately affected, similar to patterns observed in other states.[2–4] In response to the unequal distribution of the disease burden, Massachusetts lawmakers recently passed Bill H. 4672,[5] which aims to explore the racial and ethnic health inequities that have emerged amid the pandemic.

Although Black and Latino communities in Massachusetts have shouldered a larger share of the COVID-19 burden,[2,4] evidence regarding the community-level factors that may be contributing to this disparity remains sparse. Furthermore, because most data collected by departments of health focus on only a few demographic factors such as age, sex, and race/ethnicity, there has been a paucity of objective data on whether COVID-19 cases are characterized by disparities along other important dimensions. There is growing concern, for example, that lower-income and Black and Latino persons may be at greater risk for exposure to COVID-19 because they are more likely to be essential workers and also tend to live in densely populated areas and multigenerational households.[6–8] Among immigrant communities, there are reports of foreign-

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born noncitizens avoiding care (including testing and advice regarding COVID-19-like symptoms) for fear of being deported or risking their future legal resident status based on new federal "public charge" regulations.[9,10] Finally, longstanding historical inequities and structural racism, which have led to adverse outcomes including residential segregation and differences in access to health care, may also contribute to these disparities.[11–13] Therefore, an understanding of the factors leading to increased case rates among minority communities is urgently needed to inform strategies to mitigate the ongoing spread of the disease.

This study had two key objectives. First, we sought to characterize the association between the proportion of Black and Latino residents and COVID-19 cases in cities and towns across Massachusetts. Second, we evaluated what other demographic, occupational, and economic factors are associated with elevated community risk for COVID-19 and which of these factors—if any—are contributing to potential racial and ethnic disparities.

Study Data And Methods

DATA SOURCES The Massachusetts Department of Public Health database, which is publicly available on the Mass.gov website, was used to obtain the number of confirmed COVID-19 cases per 100,000 residents by city or town between January 1 and May 6, 2020.[14] The state has released exact counts of confirmed cases for most communities, including those with zero cases, but it censors values for communities with one to four total cases and simply reports "<5 cases"; for these communities (representing 0.8 percent of our weighted sample), we imputed the absolute rate at the median of this range at 2.5 and divided by the population total to convert to a rate per 100,000.

The 2013–18 American Community Survey, administered by the Census Bureau, was used to obtain demographic, economic, and occupational variables at the city and town level.[15] The primary variables of interest were the proportions of people in one of four mutually exclusive racial/ethnic groups (based on self-report): Hispanic or Latino ethnicity (referred to as Latino for brevity), Black non-Latino, White non-Latino, and other non-Latino (approximately 70 percent of whom are Asian American or Pacific Islander). Hereafter, references to Black, White, and other groups are assumed to be non-Latino. Other demographic, economic, and occupational variables at the community level were total population; average age; average household size; median household income; and the proportions of people who were age sixty or older, were male, were employed as essential workers, were foreign-born noncitizens, or completed less than a high school education. Most foreign-born noncitizens in Massachusetts are from Latin America (36.4 percent), Asia (30.4 percent), Europe (20.7 percent), and Africa (7.5 percent).[15]

We classified employed residents as essential and nonessential workers using a consensus-based approach to try to match the classification in the American Community Survey to the state's classification in the governor's March 2020 emergency order.[16] The following occupations were defined as essential: health care practitioners, technical occupations, and support services; construction and extraction; installation, maintenance, and repair (for example, electrical repairers, automotive and aviation technicians and repairers, home appliance repairers, and computer machine repairers); material moving occupation; production services (for example, electrical/electronics assemblers, engine/machine assemblers, structural metal fabricators/fitters, machinists, welders, and chemical operators); transportation (for example, flight attendants, bus drivers, taxi drivers, ambulance drivers, and ship operators/engineers); building and grounds cleaning and maintenance; food preparation and serving; personal care and service; and protective services.

STATISTICAL ANALYSIS We categorized cities and towns in our sample into quartiles on the basis of the proportion of Black residents and then analyzed population-weighted descriptive statistics. We repeated this categorization on the basis of the proportion of Latino residents.

Next we estimated linear regression models to assess the association between the proportions of each racial/ethnic group and the number of COVID-19 cases per 100,000 people in each city or town. Models were weighted by the population size of each city or town. We first performed a series of univariate analyses using each demographic, economic, and occupational variable as a predictor with COVID-19 case rates as the dependent variable. Analyses that focused on a specific race/ethnicity (for example, proportion of Black residents) as a predictor adjusted for the proportion of other racial/ethnic minority residents in a city or town (for example, proportion Latino, proportion other non-Latino). We next performed multivariable linear regression to assess what factors were independently associated with differences in COVID-19 case rates and which of those factors—if any—attenuated the observed racial/ethnic disparities after adjustment. We present two versions of the multivariable model: first, using natural units for each covariate (for example, proportion of people

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by race/ethnicity, foreign-born noncitizens, essential workers, older than age sixty, and with less than a high school education; number of people for household size; dollars for median income; and total number of people in the city or town) and, second, using normalized z-scores, which enable an apples-to-apples comparison of the strength of associations for a one-standard-deviation increase in each covariate.

We performed several sensitivity analyses. Because the "essential occupations" designation aggregates a heterogeneous set of jobs that likely have different levels of risk, we tested a model that separately identified the three most common categories of essential work in our sample: health care, food services, and construction/extraction.

To examine whether our results were being driven by a small number of large-population areas (particularly Boston), we performed sensitivity analyses with multivariable regression models limited to the fifty largest cities and towns and, separately, limited to smaller towns (all other towns not in the top fifty). We repeated all analyses using the logarithm of the COVID-19 rate as the outcome, and we also tested using the log of average household income as a covariate. We also tested whether excluding towns with censored COVID-19 rates between one and four cases affected our results.

In addition, because data on deaths at the city or town level are not publicly available, we performed county-level analyses to assess the association between proportion of Black or Latino population and number of confirmed COVID-19 cases and deaths per 100,000 population within a county. We also assessed the correlation between COVID-19 case rates and death rates within counties.[14]

The Harvard T. H. Chan School of Public Health Institutional Review Board deemed this study non–human subjects research, given the use of aggregated publicly available data. Analysis was performed using Stata, version 14.0.

LIMITATIONS There were important limitations to this study. First, in Massachusetts—as in most states and localities to our knowledge—individual-level data by race/ethnicity and other demographic, economic, and occupational variables are not currently publicly available. Because our analysis focused on community-level variables, these population-level findings may be subject to ecological fallacy. However, the broad pattern of our findings on race/ethnicity matches closely the individual-level disparities evident in other patient-level data sources.[17,18] Moreover, in the absence of individual-level demographic, economic, and occupational data, our evaluation of these factors at the level of the city or town provides the most granular level of analysis currently possible and is a considerable improvement over county- or state-based analyses.

Some factors, such as occupation in an essential service field, might not affect Black and Latino populations in a similar manner.

Second, although Massachusetts was a COVID-19 hot spot during the time of our study, these findings might not be generalizable to other US states. Although our single-state study may have limited generalizability, there is wide variation across states in testing availability and guidelines, which may bias rates of confirmed COVID-19.[19] Therefore, the focus of this analysis on a single state likely improved its internal validity to assess the predictors of COVID-19 case rates. In addition, Massachusetts has the fourth-highest median income of any state and the highest level of health coverage in the nation,[20,21] although it is unclear whether insurance coverage has any mitigating effect on rates of COVID-19 transmission and disparities.

Third, we focused on confirmed COVID-19 cases, as city and town COVID-19 death rates are not publicly available. Our county-level analysis indicates that COVID-19 case rates and death rates were highly correlated, suggesting that the pattern seen here for cases is likely similar for deaths. Unlike death rates, however, variation in case rates could be affected by differences in testing patterns across localities or other sociodemographic factors. Given known disparities in health care access and COVID-19 testing availability, the communities we identified as being at higher risk for COVID-19 may, if anything, be less likely to receive adequate testing,[19,22] which suggests that our results likely underestimate disparities in case rates.

Finally, underlying differences in comorbidities across minority groups were not captured in our study; however, this would be more likely to affect disparities in death rates rather than case rates.

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Study Results

CHARACTERISTICS OF CITIES AND TOWNS All 351 cities and towns in Massachusetts were included in the analysis. Communities with a higher proportion of Black residents or Latino residents (top quartile) had larger populations, fewer high school graduates, lower median incomes, younger residents, and more foreign-born noncitizens than communities with smaller proportions of these residents (bottom quartile), on average (exhibit 1). Average household size was slightly smaller among communities in the top quartiles of proportion Black or Latino population than among those in the bottom quartiles (2.5 versus 2.6). The proportion of people working in essential service occupations, including food preparation and service and building, grounds cleaning, and maintenance services, was higher among communities in the top quartiles of proportion Black or Latino population than those in the bottom quartiles.

RACE/ETHNICITY Cities and towns with a higher proportion of Black residents or Latino residents generally had a higher number of COVID-19 cases per 100,000 population (exhibits 2 and 3). Notably, the state's five communities with the highest COVID-19 rates are all majority-minority, including Chelsea, which has a population that is two-thirds Latino and has the highest confirmed infection rate in the state—nearly six times higher than the state average.[23]

In the unadjusted analyses of race/ethnicity (with White non-Latino the comparison group), a 10-percentage-point increase in the Black population was associated with an increase of 312.3 cases per 100,000 population ($p < 0.001$), a 10-percentage-point increase in the Latino population was associated with an increase of 258.2 cases per 100,000 ($p < 0.001$) , and a 10-percentage-point increase in the other non-Latino population was associated with an increase of 86.5 cases per 100,000 ($p < 0.001$) (exhibit 4).

After multivariable adjustment, the association between the proportion of Black population and case rates persisted, with a 10-percentage-point increase in the Black population associated

EXHIBIT 1

Characteristics of cities and towns in Massachusetts, by proportion Black or Latino population

	Proportion Black population			Proportion Latino population		
Characteristics	Bottom quartile	Top quartile	*p* value	Bottom quartile	Top quartile	*p* value
DEMOGRAPHIC VARIABLES						
Total population, mean (SD)	12,264 (7,516)	178,415 (239,038)	0.002	11,447 (5,978)	179,388 (240,985)	0.001
Age (years), mean (SD)	45.9 (3.4)	37.0 (5.4)	<0.001	45.9 (4.3)	36.4 (4.7)	<0.001
Proportion older than age 60 (%)	26.6	20.2	<0.001	26.8	19.5	<0.001
Sex (% male)	48.8	48.6	0.559	48.9	48.6	0.581
Race/ethnicity (%)						
Latino	2.1	15.3	<0.001	1.1	18.7	<0.001
Black (non-Latino)	0.2	11.1	<0.001	1.0	10.5	<0.001
White (non-Latino)	93.5	61.7	<0.001	94.2	60.2	<0.001
Other (non-Latino)	4.2	11.9	<0.001	3.9	10.6	<0.001
No. of people per household, mean (SD)	2.6 (0.2)	2.5 (0.2)	0.014	2.6 (0.3)	2.5 (0.2)	0.027
Foreign-born noncitizens (%)	1.9	10.7	<0.001	1.8	10.8	<0.001
ECONOMIC AND OCCUPATIONAL VARIABLES						
Less than high school education	5.1	12.2	<0.001	5.1	13.5	<0.001
Median household income ($)	103,210	73,506	<0.001	99,334	67,550	<0.001
Occupation in essential services (%)	38.4	42.5	0.102	39.5	44.1	0.068
Food and services preparation	4.5	6.2	<0.001	4.5	6.3	<0.001
Construction and extraction services	4.7	4.3	0.383	5.3	4.3	<0.001
Installation/maintenance and repair services	2.6	2.0	0.013	2.7	2.0	0.003
Material moving occupation	2.1	2.7	0.048	2.3	3.0	0.059
Production services	3.6	4.2	0.319	3.6	5.0	0.046
Transportation services	2.8	3.1	0.371	2.7	3.4	0.089
Building/grounds/maintenance services	2.6	3.9	0.002	2.8	4.2	0.002
Health care practitioners and technical services	2.0	1.9	0.643	1.8	1.9	0.641
Health care support services	2.5	4.2	0.002	2.7	4.6	0.001
Personal care and service occupation	2.5	3.2	0.001	2.6	3.2	0.002
Protective services	2.2	2.1	0.690	2.3	2.1	0.160

SOURCE Authors' analyses of Massachusetts Department of Public Health data, 2020, and the 2018 American Community Survey. **NOTE** SD is standard deviation.

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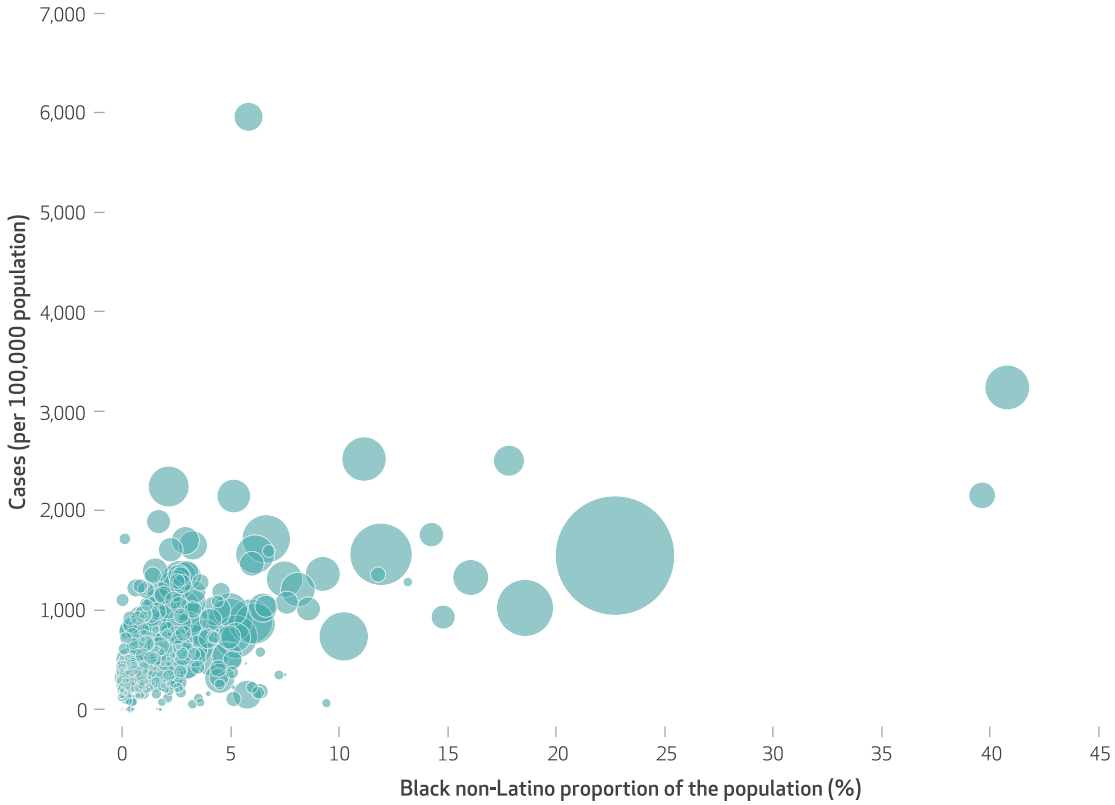
EXHIBIT 2

Proportion of the population made up of Black non-Latino residents and number of COVID-19 cases per 100,000 population across Massachusetts cities and towns



SOURCE Authors' analysis of Massachusetts Department of Public Health data, 2020, and the 2018 American Community Survey. **NOTES** The figure shows the relationship between the proportion of Black non-Latino persons residing in a city or town and COVID-19 case rates. The sizes of the circles in the figure reflect the total population size of each city and town, ranging from 48 people in the smallest town to 679,413 people in the largest city.

with an additional 307.2 cases per 100,000 population ($p < 0.001$). In contrast, the association between the proportion of Latino population and case rates was substantially attenuated and no longer significant (an increase of 50.4 cases per 100,000; $p = 0.154$). Meanwhile, after adjustment, the association between the proportion of other non-Latino population and case rates became significantly negative (a decrease of 216.4 cases per 100,000; $p < 0.001$).

DEMOGRAPHIC, ECONOMIC, AND OTHER FACTORS Several factors were significantly associated with higher COVID-19 case rates across cities and towns in unadjusted models: higher average household size and larger shares of essential workers, foreign-born noncitizens, and proportion with less than a high school education. After multivariable adjustment, mean household size and proportion of foreign-born noncitizens were still independently associated with higher COVID-19 rates. The model using normalized values (z-scores) for these covariates showed that the largest absolute risk factor was the share of foreign-born noncitizens (310.4 per one-standard-deviation increase), followed by mean household size (236.4 per one-standard-deviation increase). Older age was also associated with additional cases, whereas larger population size was associated with slightly fewer cases, but both were weaker predictors (exhibit 4).

Although the overall proportion of essential service workers was no longer associated with case rates in our multivariable analysis, an exploratory analysis of the three most common occupations found that employment in food service was significantly associated with higher case rates (71.4 per standard deviation; see online appendix exhibit 1).[24]

SENSITIVITY ANALYSES We observed a similar association between race/ethnicity and COVID-19 case rates in the multivariable analysis when we stratified the sample into the largest fifty cities and towns and all other (smaller) towns (appendix exhibit 2).[24] The proportion of for-

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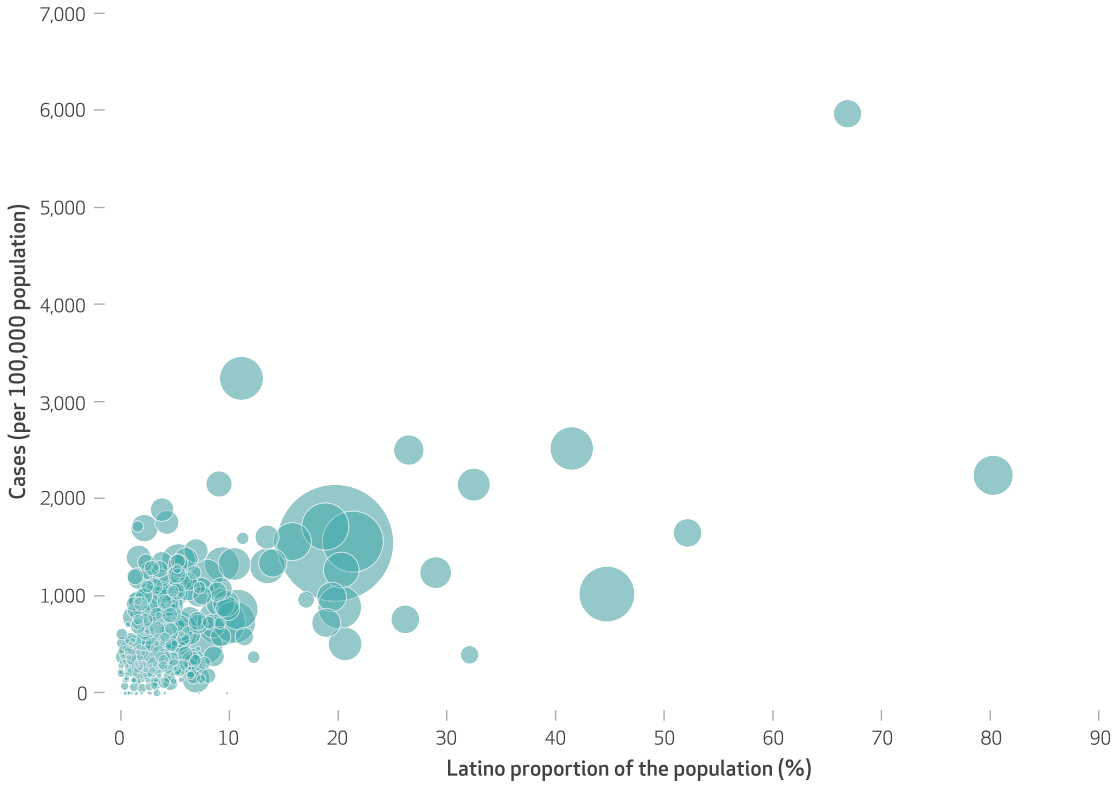
EXHIBIT 3

Proportion of the population made up of Latino residents and number of COVID-19 cases per 100,000 population across Massachusetts cities and towns



SOURCE Authors' analysis of Massachusetts Department of Public Health data, 2020, and the 2018 American Community Survey. **NOTES** The figure shows the relationship between the proportion of Latino persons residing in a city or town and COVID-19 case rates. The sizes of the circles in the figure reflect the total population size of each city and town, ranging from 48 people in the smallest town to 679,413 people in the largest city.

EXHIBIT 4

Association of race/ethnicity, demographic, economic, and occupational factors with COVID-19 case rates across Massachusetts cities and towns

	Increases in cases per 100,000 population						
	Univariate analyses[a]		Multivariable analysis[a]		Multivariable analysis using z-scores[b]		
City/town variables	**Estimate**	**95% CI[c]**	**Estimate**	**95% CI**	**Estimate**	**95% CI**	***p* value[d]**
Proportion of Black non-Latino population	312.3	241.9, 383.0	307.2	219.6, 394.7	127.2	90.9, 163.4	<0.001
Proportion of Latino population	258.2	217.0, 300.3	50.4	−19.0, 119.8	40.6	−15.3, 96.5	0.154
Proportion of other non-Latino population	86.5	7.2, 169.9	−216.4	−321.4, −111.3	−122.4	−181.8, −63.0	<0.001
City/town population size	11.5	7.9, 15.2	−4.0	−7.8, −0.24	−16.8	−32.6, −1.0	0.037
Proportion older than age 60	−546.6	−666.6, −426.4	163.9	37.8, 290.1	122.5	28.2, 216.8	0.011
Mean household size	669.4	344.0, 994.8	886.2	494.3, 1278.1	236.4	131.9, 340.9	<0.001
Proportion with less than high school education	611.9	524.0, 699.8	57.7	−115.1, 230.5	27.1	−54.0, 108.1	0.512
Median income	−87.1	−109.6, 64.6	−23.7	−69.8, 22.7	−70.4	−208.8, 67.9	0.317
Proportion of essential workers	247.1	185.3, 309.0	0.23	−120.2, 125.6	2.8	−124.3, 129.9	0.966
Proportion of foreign-born noncitizens	749.3	658.8, 839.8	791.7	587.9, 851.6	310.4	253.5, 367.2	<0.001

SOURCE Authors' analysis of Massachusetts Department of Public Health data, 2020, and the 2018 American Community Survey. **NOTE** CI is confidence interval. [a]For univariate and multivariable analyses, changes in case rates reflect a per 10-percentage-point increase in the following variables: proportion Black, Latino, other non-Latino population, older than age 60, with less than high school education, essential workers, and foreign-born noncitizens; for city/town population size, changes in case rates reflect an increase per 10,000 people; for mean household size, changes in case rates reflect a per one-person increase; for median income, changes in case rates reflect a per $10,000 increase. [b]Adjusted z-scores reflect changes in case rates per one-standard-deviation increase for all city/town variables. [c]*p* values for all univariate analyses are <0.001. [d]Adjusted *p* values are for both the multivariable analysis and the adjusted z-score analysis.

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eign-born noncitizens remained the strongest predictor of case rates in the largest cities and towns, whereas in smaller towns a larger mean household size was significantly associated with higher case rates. Results were generally similar, using the logarithm of the COVID-19 case rate as an outcome, when we excluded towns with censored values for cases between one and four, when we excluded Boston from the sample, and when we measured income using the logarithm of average household income (data not reported).

We also performed additional county-level analyses and found that a higher proportion of Black or Latino residents within a county was associated with a significant increase in county-level cases and deaths (appendix exhibits 3 and 4).[24] There was also a strong positive correlation between numbers of county-level cases and county-level deaths (Pearson's coefficient, 0.82; $p < 0.001$; appendix exhibit 5).[24]

Discussion

Across cities and towns in Massachusetts, Black and Latino populations experienced much higher rates of COVID-19 cases during the first five months of 2020. Several factors measured in our data (foreign-born noncitizen status, household size, and job type) appear to explain the higher COVID-19 case rates among Latino populations. However, it appears that these factors might not be the primary reason for higher case rates in Black populations.

Although the extent of racial and ethnic disparities has already been documented,[25–27] our study identifies important factors that are independently associated with higher COVID-19 case rates in the state. The proportion of foreign-born noncitizens was the strongest predictor of the burden of COVID-19 cases within a community, and in Massachusetts this population includes sizable numbers of both Latin American (36.4. percent) and Asian (30.4 percent) individuals.[15] Furthermore, under the Trump administration's revised public charge rule, which took effect in early 2020, lawfully present immigrants who use public benefits from local, state, or federal governments may be at risk of being denied permanent residency status. Although the Citizenship and Immigration Services website now encourages immigrants to seek care for COVID-19-like symptoms, enrollment in Medicaid at the time of COVID-19-related care may still be used in the public charge analysis.[28] Recent studies suggest that immigrant families have strong incentives not to enroll in public health insurance such as Medicaid and may avoid seeking medical care if they develop COVID-19-like symptoms and require testing.[10] In the absence of a positive test, these individuals are less likely to isolate and quarantine, which may impede public health efforts to control the spread of COVID-19.[29,30]

These issues are likely only magnified by the fact that immigrants tend to live in larger households,[31] which we also found to be an independent predictor of COVID-19 case rates. Policy approaches that reduce barriers to obtaining medical care for immigrant populations and that address crowded housing, particularly when individuals have tested positive and need to be isolated, could be important avenues for reducing disparities and slowing the spread of infection.

Our work also offers important insights into the factors that may be contributing to the higher rates of COVID-19 cases among Latino populations. As noted earlier, many Latino immigrants may be deferring necessary care for fear of risking either citizenship status under the public charge rule or possible deportation. In addition, Latino persons tend to be disproportionately employed in essential services that are public facing, particularly in the food service industry, which we found to be associated with higher COVID-19 rates. As the state moves to cautiously reopen more businesses, greater worker protections to reduce potential exposures may be needed in these jobs. Many low-income minority workers also do not have the luxury of working from home,[25] and fewer than half of Latino workers in the US have jobs with paid sick leave.[32] Although Congress expanded the availability of paid sick leave under the Coronavirus Aid, Relief, and Economic Security Act in March 2020, the law exempted workers in large firms and health care organizations, which may leave many essential workers unprotected if they contract COVID-19.[33]

Meanwhile, our results show large disparities in infection rates associated with Black populations, but these disparities do not appear to be primarily explained by the factors we examined. Other factors not examined in this study may explain the disparate impact of COVID-19 on Black populations.[12,13] Structural inequities, such as disproportionately high incarceration rates,[34] residence in areas with a higher concentration of multiunit residential buildings,[35] and de facto neighborhood segregation, which may lead to disparities in health care access and greater exposure to environmental hazards, may contribute to the spread of COVID-19 among Black populations. Transportation use may also increase the risk for exposure to COVID-19, as Black workers are more likely to use public transit to commute to work.[36]

Evidence emerging from other US cities and

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states has similarly indicated that Black and Latino populations are being disproportionately affected by COVID-19.[3,25,26] In addition, preliminary work from Massachusetts suggests that these populations also have substantially higher COVID-19 death rates.[37] Our study expands on these findings in several ways. We identify important factors (proportion of foreign-born noncitizens in a community, household size, food service occupation) that are strongly associated with the risk of developing COVID-19. In addition, we characterize the extent to which these factors, among others, may be contributing to the higher number of COVID-19 cases in Black and Latino populations. Because we evaluate each of these unique populations separately, we find that some factors, such as occupation in an essential service field, might not affect Black and Latino populations in a similar manner. Our findings provide important insights that may inform and help tailor public health and policy strategies to address the ongoing COVID-19 pandemic.

Conclusion

Across Massachusetts cities and towns, significant COVID-19 disparities are evident along multiple dimensions—particularly race/ethnicity, foreign-born noncitizen status, household size, and job type. Higher proportions of Black or Latino residents within a community were significantly associated with higher rates of COVID-19 cases. The factors examined in our study explained this relationship for Latino populations but did not appear to explain the higher rates among Black populations. Further research into the social and economic factors underlying COVID-19-related disparities and new policies to address risk factors and institutional racism will be critical to controlling the epidemic and improving health equity. ■

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