Beyond the 405 and the 5: Geographic variations and factors associated with SARS-CoV-2 positivity rates in Los Angeles County

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Brief Summary

We highlight geographic differences and the socio-structural determinants of SARS CoV-2 test positivity within Los Angeles County. Communities with high proportions of Latino/a residents, those living below the poverty line and with high household densities had higher crude positivity rates.

Abstract

Objectives: To highlight geographic differences and the socio-structural determinants of SARS-CoV-2 test positivity within Los Angeles County (LAC).

Methods: A geographic information system was used to integrate, map, and analyze SARS-CoV-2 testing data reported by LAC DPH, and data from the American Community Survey. Structural determinants included race/ethnicity, poverty, insurance status, education, population and household density. We examined which factors were associated with positivity rates, using a 5% test positivity threshold, with spatial analysis and spatial regression.

Results: Between 1 March and 30 June 2020 there were 843,440 SARS-CoV-2 tests and 86,383 diagnoses reported, for an overall positivity rate of 10.2% within the study area. Communities with high proportions of Latino/a residents, those living below the federal poverty line and with high household densities had higher crude positivity rates. Age-adjusted diagnosis rates were significantly associated with the proportion of Latino/as, individuals living below the poverty line, population, and household density.
Conclusions: There are significant local variations in test positivity within LAC and several socio-structural determinants contribute to ongoing disparities. Public health interventions, beyond shelter in place, are needed to address and target such disparities.

Introduction

Los Angeles County (LAC), like many similarly sized metropolitan regions in the United States, remains a hot spot for the SARS-CoV2 pandemic with over 150,000 infections and 3000 deaths to date.[1] Regions with comparable populations, such as New York City (NYC), have experienced a surge in cases resulting in a shortage of critical care resources, including ventilators.[2] LAC began its shelter in place policy on March 19, 2020[3] and was fortunate to avoid such a crisis early on, although recent lifting of restrictions in the early part of the summer has raised the possibility of this threat. Throughout the COVID-19 epidemic in LAC, similar to NYC and elsewhere, the pattern of infections has highlighted serious economic and racial/ethnic health disparities, with Black and Latino/a communities disproportionately burdened by infections and deaths.[4]

Many parts of the country lack data on race/ethnicity for COVID-19, which in itself is a serious barrier to achieving health equity and addressing the evident economic and racial disparities.[5] Even with rigorous collection and reporting of COVID-19 data on race/ethnicity, targeting more granular health disparities, such as barriers throughout the disease continuum (from exposure to testing to hospitalization to co-morbid conditions to death), remain challenging. It is unclear whether or not racial disparities in COVID-19 related morbidity and mortality are due to under-testing or other factors including higher rates of co-morbid conditions such as obesity, hypertension and diabetes, all of which are seen in higher proportions of Black and Latino communities due to food insecurity and structural racism (e.g, the stress of police brutality, limited access to care, higher proportion of "essential" low-income jobs due to poor education systems and impact of historical redlining on housing inequities).[6, 7]

Regardless of the myriad causes of the health disparities seen in COVID-19, widespread testing is not only a cornerstone for accurate disease surveillance and early identification of cases but is likely to be of particular importance in communities impacted by these social determinants. Access to timely and reliable testing is not only crucial for effective quarantine and isolation,[8] but also allows individuals to seek treatment earlier in their disease course if warranted. Additionally, widespread testing enables jurisdictions to potentially lift physical distancing restrictions.[9] By monitoring testing and cases across LAC, hotspots or clusters of concern and interest can be evaluated and located. The SARS-CoV2 positivity rate is the proportion of positive tests among those tested and offers insight about geographic areas of concern. The World Health Organization (WHO) has proposed a five percent positivity threshold for at least 14 days to potentially loosen physical distancing and quarantine measures to contain the epidemic.[9]

We conducted an ecological analysis of geographic areas in LAC. We used a mapping system to identify areas that surpassed the 5% positivity target threshold

suggested by the WHO. Additionally, we used geospatial models to determine the socio-structural characteristics that are associated with high positivity rates in LAC.

Methods:

Unit of analysis

To integrate data from disparate sources (i.e., US Census, LA Department of Public Health), to map, and to analyze the SARS-CoV-2 testing and diagnosis landscape, a geographic information system (GIS) was used to create a grid of hexagons, each with an area of ten square kilometers. The grid was then overlaid onto the centroids of city, community, and census tract boundaries of LAC, and relevant testing and census data were then summarized and joined to the hexagon layer based on location. The selected hexagon area (i.e., 10 sq. km) serves to reduce and balance significant variations in the areas and shapes of reporting units both within, and between, LAC census and health data (i.e., tracts, cities, communities). Hexagons without any testing or census data, those with a population of less than 1,000 inhabitants, and those without any contiguous neighbors were excluded from the analysis.

Measures

Predictor variables

Predictor variables were obtained from the 2018 American Community Survey (ACS) for each census tract and mapped to each hexagon as described above. These variables included race/ethnicity, poverty, insurance status, educational status, population density and household density. Age was included as the percentage below 18 years and above 65 years. Race/ethnicity was included as the percentage of the population who were estimated to belong to specific groups as defined by US Census Data: Non-Hispanic White, Non-Hispanic Black, Asian, and Hispanic or Latino/a. Poverty was defined as the percentage living below the federal family poverty threshold (e.g., defined as $25,926 for a family of two adults and two children).[10] Educational status was included as the percentage who completed a bachelor's degree or higher. Population density was calculated as the number of estimated individuals living in a given hexagon divided by 10, as each hexagon was 10 square kilometers. Household density was calculated as the number of estimated individuals divided by the number of households within a hexagon.

Outcome variables

Data related to SARS-CoV-2 testing and diagnosis were obtained from the LAC Department of Public Health COVID-19 surveillance dashboard (http://dashboard.publichealth.lacounty.gov/covid19_surveillance_dashboard/). Data were included up to 30 June 2020. The outcomes of interest were the SARS-CoV-2 age-adjusted testing rate, age-adjusted diagnosis rate, and the crude positivity rate. Positivity rates per hexagon were calculated by dividing the crude diagnosis counts by the crude testing counts in each hexagon (multiplied by 100).

Geostatistical Analysis

To evaluate the geographical aspects of SARS-CoV-2 outcomes across LAC, we used a geostatistical approach. It is established that a variety of social, economic, and health indicators and outcomes are not geographically random, but tend to cluster locally.[11] The clustering of similar values on a map, for example, between adjacent units of analysis (e.g., hexagons), may indicate the presence of a geographic process (e.g., community spread, herd immunity, intervention). The geostatistical assessment of such clusters, and incorporating spatial effects into our models, yields important insights into the geographical dynamics of SARS-CoV-2 outcomes in LAC.

Maps and spatial analysis using local indicators of spatial association (LISA) were used to assess whether the geographic distributions of SARS-CoV-2 outcomes are distributed randomly across LAC.[12] The null hypothesis for our analyses is spatial randomness with significance based on a conditional permutation test. The results from the spatial analysis informed the specification of the spatial regression models, which included a spatially lagged dependent variable as a predictor. For any given hexagon in our analysis, its spatial lag is equivalent to the average value of SARS-CoV-2 outcomes in adjacent, or contiguous, hexagons. Estimates from the spatial regression are not directly comparable to those obtained from ordinary least squares (OLS) regression. However, estimates from our models provide important directional insights into the linkages between the selected predictor and outcome variables. For interpretation we have included the direct, indirect and total effects. The direct effect represents the expected average change across all observations for the dependent variable of in a particular region due to an increase of one unit for a specific explanatory variable in this region. the indirect effects represent the changes in the dependent variable of a particular region arising from a one unit increase in an explanatory variable in another region. The total effect is the sum of the direct and indirect effects.

Results

A total of 184 ten-square kilometer hexagons, across LAC were used in our analyses. Between 1 March 2020 and 30 June 2020 there were 843,440 SARS-CoV-2 tests and 86,383 diagnoses reported, for an overall positivity rate of 10.2% within the included hexagons.

Maps of testing, diagnosis, and positivity show notable geographic differences across LAC (Figure 1). Areas in the highest quintile of testing are located on the westside of LAC, while the highest quintiles of diagnosis and positivity are found in central and eastern Los Angeles (Figure 1, top row). The bottom row of figure 1 maps significant ($p < 0.05$), local clusters of testing, diagnosis, and positivity. The cluster maps demonstrate that the geographic concentration of high rates of testing and low rates of positivity on the westside of LAC are opposite to the clusters of low rates of testing and high positivity rates found on the eastside of LA.

Univariate analyses show that areas with a positivity rate greater than 5% had higher percentages of Latino residents, those living below the poverty line, the uninsured, and persons without a bachelor's degree. These hexagons also were correlated with higher population and household densities (Table 1). Although the percent of Black residents living in areas where positivity was greater than 5 percent was nearly double that of those living in areas with less than 5 percent positivity, these associations were not statistically significant.

Results from the spatial regressions (Table 2) indicate that the percentage of Latinos, percentage living below the poverty line, and household density were independently associated with the positivity rate in LAC. The significant spatial lag term (i.e., rho) also confirmed that the positivity rate in one hexagon was associated with the positivity in neighboring hexagons, and may suggest community spread. Age- adjusted diagnosis rates were significantly associated with the percentage of Latinos, individuals living below the poverty line, population density, and the household density (Supplemental Table 1). None of the included variables were significant predictors of the age-adjusted testing rate (Supplemental Table 2).

Discussion

Our study reports the geographical distribution of SARS-CoV-2 positivity rates in LAC and identifies socio-structural factors associated with higher positivity for SARS-CoV-2. We found that geographic clusters of high positivity rates were located in the central part of LAC, whereas clusters of low positivity rates were located in the western part of LAC. Areas of high SARS-CoV-2 positivity were associated with high proportions of Latino/a individuals in an area, poverty, and higher household density. Our findings highlight the importance of developing targeted interventions to address the disparities that contribute significantly to the spread of COVID-19 in LAC.

Multiple interventions will be needed to mitigate the geographic and racial COVID-19 disparities in LAC. Early testing and diagnosis is key to mitigating disease transmission, as several studies have demonstrated that contagiousness is highest in the early part of the infection and perhaps even in the pre-symptomatic period.[13, 14] Lower testing in areas may result in increased disease transmission through lower awareness of infection and absence of physically distancing and other preventative measures. Requiring physical distancing is simply not feasible for many who are heavily impacted by the COVID-19 epidemic, particularly those who may live in households with several family members, or those who cannot afford to take time off from work. Ensuring universal masking may be one method to partially mitigate this disparity.

Our data also suggests that culturally appropriate interventions, especially geared towards Latino/a communities will be essential. Examples include conditional cash transfers to incentivize testing,[15] as well as economic mitigation measures for those who test positive and cannot return to work for at least two weeks.

LAC is a region with sharp geographic boundaries defined by major highways. Disparities in positivity rates are most noticeable adjacent to the two major highways, the 405 and interstate 5 (I-5). The highest testing rates and lowest positivity rates are in the affluent areas west of the 405; whereas, the highest positivity rates exist on both sides of the I-5. This suggests that housing and urban planning plays a significant role in the disparities associated with COVID-19. Many poorer Latino/a communities live in these areas of LAC in multigenerational homes in densely populated neighborhoods, a consequence in part of a long history of redlining.[16] Our models suggest that Latino/a communities are associated with high positivity rates independent of other factors (e.g, poverty and housing density) that predict positivity rates across all race/ethnicities. This suggest that other more nuanced predictors likely explain the relationship of high positivity rates in Latino/a communities. Many of those who are employed Latino/a communities work essential jobs (grocery stores, healthcare, meat packing, manufacturing and warehouses, etc) and may use public transportation to get to their workplaces. Immigration status and fear of testing and/or going to a health care facility due to fear of deportation for some Latino/a individuals may account for part of the disparities.[17]

Age-adjusted death rates for Latino/a and Black Americans is 48 per 100,000 and 43 per 100,000 compared to only 21 per 100,000 for White Americans in LAC.[18] In our study, areas with higher proportions of Black individuals were not statistically associated with higher positivity rates, but there was a trend; areas with positivity rates lower than 5% had a lower average percentage of Black American residents compared to areas with positivity rates of 5% and above. This result may be due to the concentration of the Black population within relatively few areas. Inadequate testing in areas with higher proportions of Black Americans might contribute to the observed discrepancies between mortality and positivity rates. Studies have highlighted the fact that adjusted in-hospital mortality differences among Black and White Americans are not seen, even in areas where Black Americans are disproportionately affected.[19] Therefore, it is possible that the mortality difference

more aptly reflects increased exposure as well as delayed testing, a consequence of insufficient testing or lack of access to testing facilities in those communities. Nationwide, several studies have looked at race and ethnicity as factors in disease prevalence and mortality, but these are in part shaped by the demographic composition of these regions. In studies from Georgia, Louisiana and Detroit, Michigan, regions with higher than the national average proportions of Black Americans, Black patients accounted for 83.2%, 76.9% and 72.1% of cases, respectively.[19-21] In other regions, such as the Baltimore-Washington DC area, the Latino population had a high positivity rate (42.5%), despite only accounting for 4.2% of the population.[22] In California, Latino/a individuals make up 41.5% of the total population ages 35-49 years, yet account for 77% of the deaths due to COVID-19.[23] Our findings demonstrate the higher SARS-CoV-2 positivity in communities with higher proportions of Latino/a individuals in LAC while highlighting the uneven geographical distribution of COVID-19. As more epidemiologic and hospital data is reported from the southwestern states, the impact on Latino individuals and communities may become even more apparent.

Our paper has several limitations. We focused on LAC, and our data may not be applicable to other similar sized metropolitan areas with different demographics. Additionally, based on our exclusion criteria, these results may not apply to less densely populated areas or remote parts of the county. We presented data from an ecological analysis and thus are unable to make interpretations on an individual level. Other factors may play a role in test positivity including proximity to hospitals and testing centers, as well as areas that contain skilled nursing facilities where outbreaks have been reported. Lastly, understanding additional factors that may influence disease and complication risk in certain geographic areas, such as air quality with living in majority Latino/a neighborhoods being associated with higher air pollution exposure,[24] and prevalence of other comorbid conditions, were beyond the scope of this paper.

As the communities in LAC begin to reopen, testing remains a critical feature in controlling the epidemic and continued education regarding the importance of physical distancing, particularly among infected individuals, is imperative. Reporting and analyzing COVID-19 epidemiologic data by geographic indicators can be used to focus public health resources and efforts to communities at highest need. Universal testing may be more important than contact tracing in areas with high SARS-CoV-2 positivity rates, and such a strategy has been implemented by colleagues in San Francisco.[25] Furthermore, once an effective vaccine is available, encouraging high risk communities to get vaccinated is an important strategy in containing the pandemic. Identifying communities with high SARS-CoV-2 transmission can also be a natural springboard for targeting vaccination efforts, an important strategy to contain this epidemic. Long histories of structural racism will continue to be a barrier to mitigating disease risk, improving access to care and building trust. As with any public health effort, building strong relationships with communities, ensuring trust and developing culturally appropriate interventions is a crucial first step toward dismantling the health inequities that persist throughout the country today.

Notes

Acknowledgement:

The authors listed have contributed sufficiently to the project to be included as authors, and all those who are qualified to be authors are listed in the author byline.

Potential conflicts

D.G-M. reports grant support from Gilead Sciences, outside the submitted work. All other authors have no potential conflicts.

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Table 1. Correlates of SARS-CoV-2 test positivity among 184 geographical hexagons within Los Angeles County.

	<5% mean (SD)	5 - 9.9%, mean (SD)	>=10% mean (SD)	p
n of hexagons	44	74	66	
% Age below 18	18.8 (4.80)	19.9 (3.73)	24.5 (4.08)	<0.001
% Age above 65	17.1 (5.31)	15.5 (4.40)	11.5 (3.70)	<0.001
% White	68.1 (14.33)	48.8 (19.2)	46.2 (14.1)	<0.001
% Black	4.94 (7.64)	8.55 (12.5)	8.43 (13.24)	0.223
% Asian	15.3 (9.91)	20.9 (17.9)	10.8 (12.01)	<0.001
% Latino	17.3 (13.54)	37.8 (18.7)	69.3 (18.50)	<0.001
% Poverty	4.70 (2.75)	9.93 (5.08)	16.4 (7.74)	<0.001
% Uninsured	5.36 (2.71)	8.84 (3.73)	13.6 (4.85)	<0.001
% Bachelor's degree or higher	58.3 (14.69)	35.4 (14.6)	17.4 (11.0)	<0.001
Population density per km^2	2,248 (1,547)	3,115 (1,735)	4,381 (2,363)	<0.001
Household density	2.36 (0.48)	2.84 (0.49)	3.54 (0.56)	<0.001

Table 2. Spatial lag model of socio structural correlates of **SARS-CoV-2 positivity rate** in Los Angeles County

	Estimate	Std. Error	Direct	Indirect	Total	P value
% Age below 18	-0.042	0.075	-0.042	-0.011	-0.053	0.575
% Age above 65	**0.161**	**0.068**	**0.164**	**0.041**	**0.204**	**0.018**
% Latino	**0.283**	**0.162**	**0.288**	**0.071**	**0.359**	**0.081**
% White	0.094	0.131	0.095	0.024	0.119	0.474
% Black	0.033	0.104	0.033	0.008	0.042	0.753
% Asian	-0.019	0.127	-0.019	-0.005	-0.024	0.882
% Poverty	**0.293**	**0.100**	**0.298**	**0.074**	**0.371**	**0.004**
% Uninsured	-0.015	0.117	-0.015	-0.004	-0.019	0.898
% Bachelors or higher	-0.006	0.131	-0.006	-0.001	-0.008	0.964
Population density per square kilometer	0.101	0.069	0.103	0.026	0.129	0.145
Household density per hexagon	**0.329**	**0.110**	**0.334**	**0.083**	**0.417**	**0.003**
rho – Spatial lag of positivity	**0.212**	**0.070**				**0.005**

	Estimate	Std. Error	Direct	Indirect	Total	P value

All variables were centered to a mean of 0 and scaled to a standard deviation of 1.

The spatial lag model incorporates spatial effects by including a spatially lagged dependent as an additional predictor.
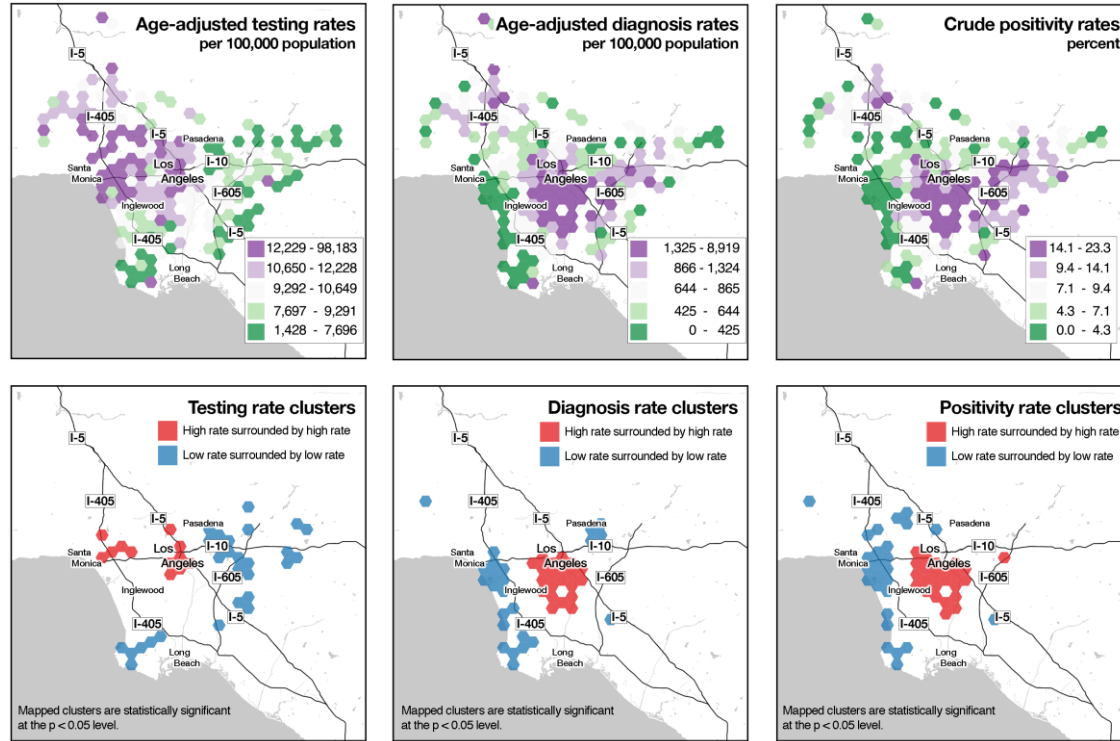
The outcome at location *a* depends (in part) on the outcome at location *b*. Thus, coefficients are not directly interpretable as in linear (OLS) regression. See text for interpretation of direct, indirect and total effects.

Figure. Quintile (top row) and cluster (bottom row) maps of SARS-CoV-2 testing, diagnosis, and positivity rates across Los Angeles County.

Figure 1