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Social Vulnerability to COVID-19 Pandemic in California Cities

Dr. XiaoHang Liu
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The PACE Applied Housing Research Initiative (AHRI) seeks to expand faculty research on housing to make PACE a central hub where students, policy makers, practitioners, and other housing leaders can come together to examine and understand housing policy issues in the Bay Area and beyond. AHRI provides a platform for introducing innovative solutions to affordable housing problems through activities such as supporting faculty and student research, offering a practitioner (co)-taught course on housing, and hosting an annual Distinguished Speaker Lecture. Seed funding from Merritt Community Capital Corporation for AHRI is greatly appreciated.

Abstract

The COVID-19 pandemic underscores the urgency to advance social justice in housing markets. This research aims to identify the population most vulnerable to COVID-19 and the social determinants behind their vulnerability. Based on the 145 largest cities in California, this study found that a city's vulnerability to COVID-19 was strongly associated with its socioeconomic status, household composition, minority population, and housing characteristics. Lower educational attainment and single-parent household status impact COVID-19 vulnerability together with income, minority population status and healthcare access. Over-crowdedness, rent burden, and homeownership cost burden were also important, affirming the necessity of stable and affordable housing during the pandemic. A social vulnerability index, COVID SVI, was built to compare cities' vulnerability. Results show that there exists a wide regional variation in California. Cities in the San Francisco Bay Area were found the least vulnerable while cities in Los Angeles County were found the most vulnerable. A pair of cities in each California region was identified for further research on their Inclusionary Housing (IH) policies.

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INTRODUCTION

The COVID-19 pandemic has brought unexpected and unprecedented changes to people across the globe. How much resource an individual can access greatly impacts his/her exposure to COVID-19 and its ensuing economic and health consequences. People of low socio-economic status (SES) are more likely to live in poor housing conditions and overcrowded neighborhoods, more likely to lose their job due to government responses to COVID-19, and even if employed, more likely to be in occupations that do not provide opportunities to work from home; thus they are more likely to contract the disease while their financial stress is being exacerbated. Unfortunately, low-SES people are also more likely to have limited or no health insurance and less willing to use healthcare services even if they do have access (Becker & Newsom, 2003). These factors synergistically make low-SES communities much more vulnerable to COVID-19 pandemic and its impact.

To guide adaptation and build resilience in the most vulnerable communities, knowledge on the social determinants of a community's vulnerability to COVID-19 is necessary. One such determinant is housing which has been called for urgent policy intervention during the pandemic. Housing affordability and stability have been linked with poor physical and mental health outcomes (Pierse et al., 2016) and crowded housing is known to elevate its residents' risk of exposure to communicable diseases (Krieger & Higgins, 2002). Research on U.S. counties in April 2020 found that each 5% increase in households with poor housing conditions resulted in 50% higher risk of COVID-19 incidence and a 42% higher risk of COVID-19 mortality (Ahmad et al., 2020).

Before the COVID-19 pandemic, there was already a housing crisis in California. In 2019, 53.3% renters paid more than 30% of their monthly household income on rent and utilities and 51.6 % homeowners paid more than 35% of their income toward housing expenses (American Community Survey 2019). The COVID-19 outbreak in 2020 exacerbated the crisis. Emerging data shows that 1 in 7 adult renters in California are delinquent on rent payment and an estimated 10.1 million adults are in a household that is falling behind its mortgage payment

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[1] This paper is based on a proposal, coauthored with Professors Ayse Pamuk, Jennifer Shea and Laura Mamo, all at San Francisco State University, on rethinking IH policies in light of the COVID-19 Pandemic in California.

[2] XiaoHang Liu, Ph.D. Professor of Geography and Environment, San Francisco State University, xhliu@sfsu.edu.

(Center on Budget and Policy Priorities, 2020). With state-wide social distancing guidelines and stay-at-home orders, access to safe, stable, and affordable housing is more important than ever.

Inclusionary affordable housing is developed to increase housing affordability and promoting housing stability thus hold the potential to level the health and economic playing field for vulnerable populations. In response to the calling for urgent policy intervention during the pandemic, some California municipalities have either relied on existing inclusionary housing policies or adopted emergency housing policy tools. However, whether and how inclusionary housing policies are used to stabilize housing for renters and homeowners, as well as to mitigate the inequitable housing effects of COVID-19, have not been examined. To lay the groundwork of research on this subject, this study will first identify the social determinants most impacting a city's vulnerability to COVID-19, then find the most vulnerable cities in California. Five pairs of cities are then recommended for a subsequent research which will compare and contrast their inclusionary housing programs so as to assess the effectiveness of inclusionary housing in reducing social vulnerability and enhancing equity.

METHODS

Social Determinants of COVID-19 Vulnerability

A starting point to identify the social determinants impacting a city's COVID-19 vulnerability is the determinants used by the Center of Disease Control Social Vulnerability Index (CDC SVI). CDC SVI determines the resilience of communities to natural and anthropogenic disasters such as hurricanes, disease outbreaks, or exposure to dangerous chemicals (Flanagan et al., 2018). It uses 15 determinants covering four dimensions: (1) socioeconomic status described by educational attainment, income, poverty, unemployment, and access to health insurance; (2) household composition/disability described by single-parent households, seniors and children population; (3) minority status/language described by minority population and English fluency; and (4) housing/transportation described by over-crowdedness, multi-unit residence, mobile homes, group quarter living, and vehicle ownership. Table 1 in Section 3 provides the details of each determinant.

One distinct change brought by COVID-19 is the risk of sudden loss of income which greatly impacts housing affordability and stability. Recent data has shown that millions in California are falling behind on their rent or mortgage payments (Center on Budget and Policy Priorities, 2020). Since CDC SVI does not take this aspect into account, the housing/transportation dimension was expanded by adding two determinants: rent burden measured by the percent of occupied units paying more than 30% of monthly income for rent, and house ownership burden measured by the percent of housing units whose owner costs exceeds 30% of income. Extreme rent burden measured by the percent of housing units spending more than 50% of their income was also examined.

The number of COVID-19 confirmed cases in each city as of January 4th 2021, then again as of February 1st 2021, was collected from Los Angeles Times "Tracking the Corona Virus in California" project which "conducts an independent, continual survey of dozens of local health agencies across the state." (Los Angeles Times 2021). Several counties such as Santa Barbara and Modesto have data available only by zip codes. Under such circumstances, city-level

estimates were made by aggregating the cases in the zip codes in each city. COVID-19 incidence rate, i.e., number of incidences per 100,000 people, was calculated by normalizing COVID-19 cases by the city's population count.

Data of the 17 determinants were collected from the 2019 one-year American Community Survey (2019) which provides data for cities with a population over 65,000. 145 cities in California were thus included in this study. Based on the delineation of geographical regions by the Public Policy Institute of California (PPIC 2021), 26 cities fall in the Central Valley region, 31 cities in the San Francisco Bay Area region, 29 cities in the Los Angeles region, 25 in the Orange-San Diego region, 23 in the Inland Empire region, and 11 in the rest of California. Several cities had missing data on several determinants. Under such circumstances, the corresponding 2019 ACS 5-year data were used as substitutes.

The association between each social determinant and COVID-19 incidence was calculated using Pearson's correlation coefficient. A coefficient value between -0.4 and 0.4 suggests weak association; the corresponding determinant was then deemed insignificant to COVID-19 vulnerability. After the significant determinants were identified using COVID-19 incidences by January 4, 2021, the results were validated using COVID-19 incidence data by February 1st 2021.

COVID-19 Social Vulnerability Index (COVID SVI)

To quantify community vulnerability to COVID-19, a COVID-19 Social Vulnerability Index (COVID SVI) was developed based on the social determinants identified as moderately or strongly associated with COVID-19 prevalence in the previous section. Following CDC SVI, a percentile was calculated based on each determinant to measure a city's vulnerability due to that determinant when compared with other cities in California. Thus, if a city scores 0.95 in unemployment, it is because this city's unemployment rate was higher than 95% of all cities, thus being more disadvantaged and vulnerable. The percentile of each determinant in each city was calculated and summed over each of the four dimensions: socioeconomic status, household composition/disability, minority status/language, and housing/transportation. The grand total of the four dimensions is a city's COVID SVI value, telling the city's vulnerability to COVID-19 compared to other cities in California.

Inclusionary Housing (IH) Programs in California

As of 2020, there were 226 Inclusionary Housing (IH) programs in California. Data on these programs were retrieved from the Inclusionary Housing Database by Ground Solutions Network (2020). A few programs are countywide (e.g., Marin County) but the majority is at city level. Some cities like San Francisco have multiple programs while others have only one. Based on this dataset, each of the 145 cities included in this research was marked as either having an inclusionary housing program or not.

Selection of Paired Cities

With COVID SVI and Inclusionary Housing program data available for each city, five pairs of cities were identified for future in-depth comparison and contrast analysis of their inclusionary housing policies, one pair for each major geographical region - Central Valley, San

Francisco Bay Area, Los Angeles County, Orange-San Diego area, and the Inland Empire area. The selection was based on two principles: Each pair must have one city with IH programs and the other city without; whenever possible, the two cities should be similar in COVID-19 vulnerability as measured by the overall COVID SVI as well as each of the four sub-components.

RESULTS AND DISCUSSION

COVID SVI Determinants

Among the 17 social determinants examined, 9 were found moderately or strongly associated with COVID-19 incidence rate thus included in COVID SVI. Among them, educational attainment and single parenthood have the strongest association ($r > 0.7$); income, health insurance, minority population, and over crowdedness are also strong determinants ($r > 0.6$) while unemployment, rent burden, and homeownership burden are moderate ($r > 0.4$). Poverty, disability, English fluency, mobile home, group quarter living, and vehicle ownership were found weakly associated with COVID-19 incidence ($r < 0.4$). All four subcomponents of COVID SVI, based on the 9 moderate or strong determinants, were highly correlated with COVID-19 incidence rate, with socioeconomic status being the strongest ($r = 0.71$) and housing/transportation the weakest ($r = 0.66$). When all subcomponents are combined, the overall COVID SVI is strongly associated with COVID-19 prevalence ($r = 0.8$).

That the 17 determinants have unequal impacts on a community's vulnerability to COVID-19 reveals some unique risks of COVID-19. Like Hawkins et al. (2020) and Wiemers et al., (2020) reported, educational attainment emerged as the strongest determinant outstripping other determinants that had been expected to have equal or stronger impact. A probable explanation is that people with low educational attainment, marked as having no high school diploma, are mostly employed in jobs as frontline workers. They do not have the benefit of working from home, a critical factor to reduce the chance of contracting the disease. Another strong determinant is the percent of single-parent households in a city. Single-parent families are more dependent on the schools to help with childcare; public school closing in California thus had a greater impact on them.

On the other hand, unemployment unexpectedly had only moderate association with COVID-19 prevalence ($r = 0.46$). Previous research has found that higher unemployment was associated with fewer COVID-19 fatalities (Hawkins et al., 2020). These findings regarding unemployment, together with the finding that low educational attainment strongly impact COVID-19 incidence, suggests the possibility that a significant number of COVID-19 contractions were from workplace. Frontline jobs are disproportionally low-paying and without a requirement of an advanced degree thus attract primarily people with low educational attainment. Unemployment enables people to stay away from workplace; thus reduces the risk of contracting COVID-19. Another unexpected result is that, though generally speaking, higher percentage of elder population elevates a community's vulnerability to natural or anthropogenic disasters, this research found that higher percentage of senior population reduces a city's vulnerability to COVID-19, perhaps because, by early 2021, the elders have taken proactive steps to protect themselves against COVID-19.

The varying impact of different determinants, some counterintuitively, suggests that COVID-19 pandemic is not the same as other distress or disaster; development of metrics specific to COVID-19 vulnerability is thus necessary. In the literature, research has used general indices such as CDC SVI (Nayak et al. 2020) or Distressed Community Index (Hawkins et al., 2020) to assess vulnerability to COVID-19. However, a pre-existing index may contain determinants weakly associated or even protective against COVID-19, rendering the index less sensitive to COVID-19 vulnerability. In this research, 8 of the 15 determinants used by CDC SVI were found weakly associated with COVID-19 incidence rate. This explains why the association between CDC SVI and COVID-19 incidence was insignificant (Nayak et al. 2020), but very strong once CDC SVI was modified to COVID SVI (r = 0.8).

Table 1: COVID-19 Social Vulnerability Index (SVI)

	Determinants	Correlation Coefficient (r)
Socioeconomic status (r = 0.77)	Percent persons with high school education or less	0.78
	Percent persons with no health insurance	0.66
	Median household income	0.68
	Percent civilian unemployed	0.46
	Percent individuals below poverty	0.40.35
Household composition & disability (r = 0.70)	Percent single-parent households	0.74
	Percent persons 65 years of age or older	-0.43
	Percent persons more than 5 years old with a disability	0.15
Minority status / Language (r = 0.66)	Percent of Black/African American, non-white Hispanic, Native Indian	0.66
	Percent of people (5+) who does not speak English well or not at all.	0.34
Housing & Transportation (r = 0.64)	Percent occupied housing units with more than one person per room*	0.60
	Percent housing units with 10 or more units in structure	-0.31
	Percent housing units that are mobile homes	0.21
	Percent of persons in group quarters (e.g., homeless shelters, group living)	0.0
	Percent households with no vehicle	-0.08
	Percent of occupied units paying more than 30% for rent	0.41
	Percent of housing units whose owner costs exceeds 30% of income	0.44

Note: Determinants greyed out were not included in COVID SVI because of their weak correlation with COVID-19 incidence rate.

Like other research, this study also found that race and ethnicity strongly impact COVID-19 vulnerability. White, especially non-Hispanic White population, is strongly associated with reduced COVID-19 risk (r = -0.66). In contrast, minorities and people of color are much more vulnerable. This study aggregated non-White Hispanic, Black and American Indian as minority population because of their positively association with COVID-19 incidence. However, a closer examination revealed that non-White Hispanics had much stronger association with COVID-19 risk (r = 0.66) compared to Black/African American (r = 0.25) and Native American Indian (r = 0.22). This calls for more nuanced examination on how race and ethnicity impact COVID-19 vulnerability.

Of interest to research on housing during pandemic is that rent burden and homeownership burden, though only moderately associated with COVID-19 prevalence, were stronger determinants than many other housing factors. Notably, mobile homes, high density housing (e.g., 10+ units in a house), and group quarter living were not meaningfully associated with high COVID-19 prevalence. Neither was vehicle ownership. In fact, among the housing/transportation determinants used by CDC SVI, only over-crowdedness was found to be a strong predictor of COVID-19 incidence. This finding seems to suggest that housing type does not impact the risk of contracting COVID-19. Instead, one's ability to maintain a living space, either through renting or owning, is more important, affirming the calls for affordable, stable, and uncrowded housing during the pandemic.

COVID SVI Pattern

The overall COVID SVI of the 145 cities ranged widely from 0.64 to 8.56, with Palo Alto being the least vulnerable and Florence-Graham CDP being the most vulnerable. Overall, the San Francisco Bay Area is the least vulnerable region; Central Valley and Orange-San Diego are moderate; Los Angeles and Inland Empire are most vulnerable. A close look reveals that San Francisco Bay area primarily benefits from its advantage in the socioeconomic status dimension. Characterized by a large number of hi-tech companies, the Bay Area has much higher educational attainment and median household income than the rest of California. Interestingly, despite the Bay Area is most expensive in California in terms of housing price and rent, it is least vulnerable in the housing dimension compared to the other regions. Central Valley and Orange-San Diego region are similar in overall COVID SVI, but Central Valley is much more disadvantaged than Orange-San Diego except in the housing dimension. The Los Angles region is the most vulnerable in all four dimensions. In particular, it has the highest percentage of minority population, highest percentage of single-parent households, worst housing conditions, and worst socioeconomic status. These characteristics are shared by Inland Empire which is only slightly less vulnerable. Table 2 and Figure 1 summarize the regional variation in COVID SVI. Details of each region are provided in the Appendices.

Suggested Paired Cities in Each Region

Among the 145 cities studied, 45 have citywide IH programs. Twenty three such cities are located in the San Francisco Bay Area, where the counties of Contra Costa, Marin, San Francisco, Napa, San Mateo, Sonoma also have countywide programs; 4 in Los Angeles County which has a countywide density bonus program; 7 in the Orange-San Diego region; 5 in the Central Valley region where the counties of Sacramento and Sutter have countywide programs; 2

in the Inland Empire region; 4 in the other region where the counties of Santa Barbara, Santa Cruz, Monterey have Inclusionary Housing programs.

Table 2. Summary of COVID SVI in California cities by region

		Socioeconomic	Household	Minority	Housing	COVIDSVI
San Francisco Bay (31)	range	0.06-2.87	0.03-0.90	0.01-0.97	0.29-2.21	0.64-6.68
	mean	1.14	0.32	0.47	1.07	3.01
	median	1.12	0.27	0.49	0.99	2.68
Los Angeles (29)	range	0.66-3.90	0.01-1.00	0.06-0.99	0.78-2.92	2.10-8.56
	mean	2.49	0.60	0.70	1.99	5.76
	median	2.59	0.66	0.78	2.09	6.19
Central Valley (26)	range	0.55-3.78	0.01-0.95	0.06-0.91	0.31-2.16	1.00-6.71
	mean	2.27	0.57	0.44	1.16	4.44
	median	2.36	0.64	1.47	1.18	4.49
Orange-San Diego (25)	range	0.41-3.09	0.07-0.78	0.01-0.96	0.78-2.50	1.49-6.89
	mean	1.81	0.39	0.29	1.67	4.16
	median	1.99	0.38	0.24	1.71	4.11
Inland Empire (23)	range	0.83-3.57	0.12-0.99	0.27-0.98	0.76-2.43	3.13-7.71
	mean	2.47	0.66	0.67	1.65	5.45
	median	2.55	0.64	0.71	1.76	5.82
Other (9)	range	0.78-3.17	0.22-0.98	0.08-1.00	0.59-2.38	2.73-7.06
	mean	1.95	0.52	0.31	1.63	4.41
	median	1.69	0.39	0.25	1.80	3.48
California (143)	range	0.06-3.90	0.01-1.00	0.01-1.00	0.29-2.92	0.64-8.56
	mean	2	0.5	0.5	1.51	4.51
	median	2.04	0.5	0.5	1.44	4.38

For the San Francisco Bay Area, I suggest Vallejo city in Solano County and Richmond city in Contra Costa city as the pair. The two cities, similar in population count, have nearly the worst vulnerability in all four dimensions. Richmond city has an IH program as well as a countywide program while Vallejo has neither. Both cities have a rather large percentage of minority population. Vallejo has 20% African American and 26% Hispanic; Richmond has 20% Black/African American and 42.5% Hispanic or Latino. Other cities may also serve as the pair since many Bay Area cities have IH programs.

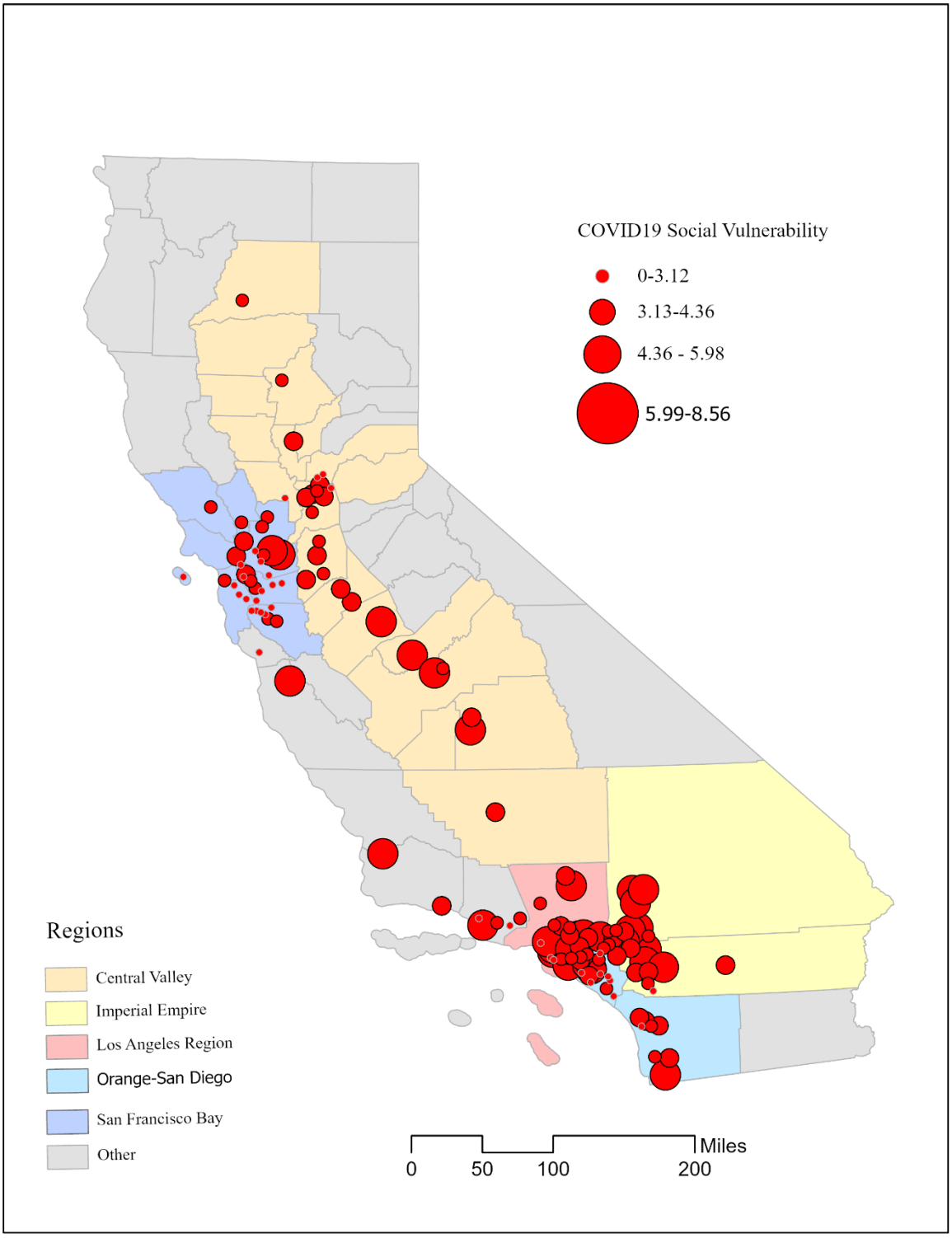

Figure 1. The spatial distribution of COVID SVI.

For the Los Angeles County region, selection of the paired cities is more challenging because only four cities have IH. Los Angles city is too large to find a comparable in population, and Pasadena has rather low vulnerability. Burbank and Glendale are somewhat moderate in vulnerability, but neither Burbank nor Glendale have high percentage of minority population. I suggest Glendale and Lancaster as the pair because of their similar sizes and similar overall COVID SVI, though Lancaster has a much higher minority population.

For the Orange – San Diego region, I suggest Chula Vista in San Diego County and Santa Ana in Orange County. Santa Ana, which has IH, is the most vulnerable city to COVID-19 in this region; Chula Vista is only slightly better. They are similar in the housing and household dimensions. Both have high percentage of minority population - Santa Ana is higher than 96% of California cities while Chula Vista is about state median.

For the Central Valley region, the challenge is that, out of the five cities having IH, four are least vulnerable in the region. I recommend Sacramento in Sacramento County and Bakersfield in Kern County as the pair. Sacramento is larger than Bakersfield, but the two cities have similar scores in the minority dimension.

In the Inland Empire region, Fontana in San Bernardino County and Temecula in Riverside County are the only two having IH. Temecula city is the least vulnerable in the region and has much fewer population than Fontana. Fontana, whose vulnerability sits in the middle among the cities in this region, was thus selected. I suggest it to be paired with Riverside city in the Riverside County.

Outside the above five regions, there are 9 cities of which 4 have IH. If studied, I suggest Salinas in Monterey County and Santa Maria in the Santa Barbara County as the pair. Both counties have countywide IH programs. Salinas, being the most vulnerable city in the region, also has a citywide program. Salinas and Santa Maria are quite similar in all four sub-components of COVID SVI. Notably, both have over 70% Hispanic or Latino population.

DIRECTIONS FOR FUTURE RESEARCH

The COVID-19 pandemic outbreak and government responses to it have dramatically impacted our society. While it is long known that burdens, resources, and opportunities are unevenly distributed in cities across California, COVID-19 has brought the inequality to spotlight and enlarged it. Moreover, it has great potential to continue amplifying the existing inequalities into the future (Haase, 2020). Identifying the most vulnerable population and the determinant behind their vulnerability is important as it serves as the first step to improve social justice.

This research identified the social determinants that are most related to a city's COVID-19 incidence rate, evaluated the vulnerability to COVID-19 in California cities, and made suggestions on five paired cities for further research in each geographical region. It is noteworthy that this is the first research conducted at the city level where IH are typically administrated. Its findings are thus particularly relevant to policy making on improving housing justice. The city-level examination also offers insights on whether a determinant's impact on COVID-19

vulnerability is scale dependent. It is well known in spatial science that research based on different scale and/or different spatial units may result in different findings, i.e. the Modifiable Areal Unit Problem (Openshaw 1981). Cross-scale analyses are thus necessary to fully understand the impact of each determinant. In the literature, most research on COVID-19 vulnerability were conducted at the county or zip code levels. More analysis at the city level is needed especially if the aim is to inform affordable housing policies.

This research can benefit from several improvements. The first is that a city's COVID-19 prevalence in this study was calculated by normalizing its incidences by its population count. Considering that age and pre-existing illness strongly impact risk to COVID-19, a more accurate measurement is to adjust COVID-19 incidences by the city's senior population and people with pre-existing conditions like in Ong et al. (2021) and Hawkins et al. (2020). The challenge is that, while data on pre-existing illness is obtainable at county and zip code level (e.g. Hawkins et al., 2020), its availability at city level is not clear. The geo-coded data from California Health Interview Survey may be a possibility (CHIS, 2021).

Another improvement is to have more nuanced examination of ethnic and racial groups when studying the impact of race to COVID-19 risk. This research included only Hispanic, Black/African Americans, and American Indian/Alaska Natives as Minority because Asian, White, and Pacific Islanders were found negatively associated with COVID-19 risk. However, no race/ethnic group is homogenous, there are wide differences in well-being within and across ethnic groups. For example, Cambodians, Hmong people, and Laotians are generally more vulnerable than other ethnic groups among Asian Americans (Ong et al., 2021). More nuanced examination of ethnic and racial groups is necessary to have all disadvantaged minority groups taken into account.

A community's vulnerability to COVID-19 is impacted by many determinants. Ong et al. (2021) summarized the determinants into several types: pre-existing conditions, built-environment risk factors, barriers that increase difficulty in accessing COVID-19 and other general healthcare services, and social vulnerability. This study strived to be comprehensive by including most potential determinants. Nevertheless, other factors also matter. Future research may examine additional determinants such as housing density, population density, access to nearby parks and open space, and lack of broadband Internet. Because determinants may correlate with each other, e.g. median income and unemployment rate, future research may also consider to weigh the determinants differently using statistical methods such as principal component analysis as in Kim & Bostwick (2020). Such improvements will acknowledge the uniqueness of COVID-19 pandemic, thus have the potential to better guide policies in addressing the opportunities and challenges brought by COVID-19 and its aftermath.

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Appendix 1. COVID SVI of Cities in the San Francisco Bay Area Region

City	County	IH	Population	Social	Household	Minority	Housing	COVID SVI
Palo Alto	Santa Clara	Y	64,864	0.06	0.24	0.05	0.29	0.64
Pleasanton	Alameda	Y	81,589	0.21	0.04	0.04	0.47	0.76
San Ramon	Contra Costa		75,958	0.45	0.03	0.01	0.49	0.99
Livermore	Alameda	Y	89,850	0.32	0.05	0.22	0.45	1.03
Walnut Creek	Contra Costa	Y	69,398	0.24	0.34	0.09	0.65	1.32
Sunnyvale	Santa Clara	Y	152,130	0.45	0.17	0.22	0.62	1.47
Fremont	Alameda	Y	240,437	0.37	0.14	0.21	0.77	1.49
Santa Clara	Santa Clara		129,970	0.64	0.17	0.24	0.71	1.76
Mountain View	Santa Clara	Y	82,325	0.50	0.10	0.14	1.01	1.76
Milpitas	Santa Clara		81,540	1.04	0.03	0.41	0.55	2.03
Berkeley	Alameda	Y	121,010	1.17	0.09	0.31	0.73	2.29
Alameda	Alameda	Y	76,349	0.66	0.46	0.50	0.73	2.35
San Mateo	San Mateo	Y	104,084	0.84	0.06	0.49	0.99	2.38
San Francisco	San Francisco	Y	877,730	0.96	0.10	0.43	0.95	2.44
Redwood City	San Mateo	Y	85,054	0.77	0.34	0.56	0.90	2.56
South San Francisco	San Mateo	Y	67,628	1.13	0.22	0.45	0.89	2.68
Union City	Alameda	Y	73,954	0.53	0.32	0.51	1.36	2.72
San Jose	Santa Clara	Y	1,018,336	1.34	0.41	0.46	1.15	3.36
Fairfield	Solano		114,664	1.18	0.81	0.63	0.77	3.39
Vacaville	Solano		91,281	1.34	0.45	0.59	1.02	3.41
Daly City	San Mateo	Y	105,876	1.24	0.20	0.43	1.55	3.43
Concord	Contra Costa	Y	128,700	1.12	0.31	0.59	1.50	3.52
Napa	Napa	Y	77,314	1.79	0.21	0.54	1.04	3.58
San Leandro	Alameda	Y	88,351	1.69	0.27	0.64	1.01	3.62
Santa Rosa	Sonoma		174,830	1.87	0.33	0.66	1.42	4.28
Hayward	Alameda	Y	157,853	1.41	0.64	0.80	1.49	4.33
Oakland	Alameda	Y	431,488	1.94	0.58	0.92	1.49	4.93
Vallejo	Solano		121,201	2.16	0.67	0.81	1.90	5.55
Richmond	Contra Costa	Y	109,648	2.43	0.50	0.97	2.05	5.96
Pittsburg	Contra Costa	Y	72,374	2.87	0.76	0.88	2.10	6.62
Antioch	Contra Costa		111,230	2.69	0.90	0.87	2.21	6.68

Appendix 2. COVID SVI of Cities in the Los Angeles County Region

City	IH	Population	Social	Household	Minority	Housing	COVID SVI
Torrance		142,548	0.66	0.15	0.44	0.85	2.10
Santa Monica		89,432	1.25	0.02	0.20	0.78	2.25
Redondo Beach		66,634	1.00	0.01	0.13	1.25	2.40
Pasadena	Y	139,871	1.50	0.16	0.68	1.20	3.55
Lakewood		78,883	1.36	0.57	0.66	1.31	3.90
Santa Clarita		212,637	1.24	0.37	0.39	1.94	3.94
Burbank	Y	102,102	2.09	0.11	0.26	1.77	4.23
Carson		91,276	2.06	0.26	0.90	1.12	4.34
Alhambra		83,113	2.13	0.28	0.57	1.53	4.52
Whittier		84,583	1.58	0.49	0.85	2.00	4.92
West Covina		104,550	1.80	0.66	0.84	1.82	5.12
Glendale city	Y	198,140	2.59	0.52	0.06	2.17	5.33
Lancaster		151,849	2.33	0.97	0.79	1.74	5.83
Downey		110,629	2.48	0.57	0.70	2.41	6.17
Long Beach		459,608	2.83	0.63	0.75	1.98	6.19
Bellflower		76,086	2.78	0.85	0.95	2.06	6.65
Los Angeles	Y	3,949,197	2.97	0.55	0.78	2.37	6.66
Pomona		150,391	2.92	0.83	0.87	2.09	6.70
Palmdale		154,847	2.88	0.85	0.83	2.19	6.74
Norwalk		103,217	2.58	0.90	0.92	2.54	6.93
Inglewood		107,802	2.97	0.86	0.99	2.11	6.94
Hawthorne		85,634	2.94	0.80	0.74	2.64	7.12
Baldwin Park		74,922	3.22	0.87	0.82	2.24	7.14
El Monte		114,662	3.41	0.69	0.71	2.61	7.42
East Los Angeles		119,714	3.52	0.92	0.94	2.09	7.47
South Gate		93,265	3.76	0.80	0.78	2.49	7.83
Compton		95,310	3.59	1.00	0.99	2.78	8.35
Lynwood		66,909	3.84	0.97	0.89	2.81	8.50
Florence-Graham		70,149	3.90	0.82	0.93	2.92	8.56

Appendix 3. COVID SVI of Cities in the Orange-San Diego Region

City	County	IH	Population	Social	Household	Minority	Housing	COVID SVI
Lake Forest	Orange		85,353	0.50	0.07	0.15	0.78	1.49
Newport Beach	Orange		84,251	0.41	0.23	0.03	0.94	1.62
Yorba Linda	Orange		67,419	0.66	0.08	0.02	1.44	2.20
Carlsbad	San Diego	Y	114,946	1.24	0.08	0.01	0.97	2.29
Irvine	Orange	Y	287,130	0.89	0.38	0.03	1.02	2.33
Mission Viejo	Orange		93,852	0.64	0.19	0.15	1.45	2.43
San Clemente	Orange	Y	64,191	0.73	0.15	0.19	1.39	2.47
Huntington Beach	Orange		198,877	1.23	0.25	0.41	0.79	2.69
Laguna Niguel	Orange		66,285	1.22	0.35	0.16	1.84	3.57
Orange	Orange		134,088	1.99	0.29	0.20	1.52	3.99
Buena Park	Orange		81,487	2.21	0.13	0.31	1.36	4.01
San Marcos	San Diego		96,316	1.55	0.48	0.24	1.83	4.10
San Diego	San Diego	Y	1,384,227	2.02	0.38	0.40	1.31	4.11
Fullerton	Orange		137,717	1.80	0.31	0.17	2.08	4.36
Costa Mesa	Orange		112,499	2.43	0.27	0.65	1.41	4.76
Tustin	Orange		79,229	1.69	0.65	0.47	2.42	5.23
Oceanside	San Diego	Y	171,258	2.41	0.44	0.45	1.94	5.25
Vista	San Diego		99,702	2.71	0.74	0.11	1.71	5.27
El Cajon	San Diego		100,917	2.69	0.53	0.50	1.97	5.69
Anaheim	Orange	Y	348,028	2.48	0.56	0.34	2.32	5.71
Garden Grove	Orange		171,030	2.50	0.54	0.23	2.50	5.77
Westminster	Orange		90,440	2.73	0.52	0.33	2.25	5.84
Escondido	San Diego		150,535	2.67	0.71	0.29	2.31	5.98
Chula Vista	San Diego		267,862	2.64	0.72	0.52	2.14	6.03
Santa Ana	Orange	Y	328,971	3.09	0.78	0.96	2.06	6.89

Appendix 4. COVID SVI of Cities in the Central Valley Region

City	County	IH	Population	Social	Household	Minority	Housing	COVID SVI
Folsom	Sacramento	Y	76,335	0.55	0.01	0.13	0.31	1.00
Roseville	Placer		140,615	0.72	0.43	0.07	0.36	1.58
Rocklin	Placer		68,398	0.92	0.18	0.06	0.98	2.14
Davis	Yolo	Y	69,232	2.01	0.06	0.10	0.92	3.08
Clovis	Fresno		114,246	1.32	0.70	0.52	0.70	3.24
Redding	Shasta		91,334	2.20	0.51	0.10	0.47	3.28
Chico	Butte		102,599	2.35	0.20	0.29	0.56	3.40
Carmichael	Sacramento		66,380	1.79	0.50	0.08	1.18	3.55
Elk Grove	Sacramento	Y	174,479	1.44	0.43	0.55	1.21	3.63
Manteca	San Joaquin		82,784	1.69	0.73	0.38	1.38	4.19
Lodi	San Joaquin		67,035	2.58	0.13	0.60	0.94	4.24
Rancho Cordova	Sacramento	Y	74,851	2.04	0.62	0.61	1.17	4.43
Citrus Heights	Sacramento		87,432	2.46	0.48	0.27	1.24	4.45
Visalia	Tulare		133,561	1.98	0.71	0.80	1.02	4.52
Sacramento	Sacramento	Y	509,254	2.32	0.69	0.76	0.83	4.60
Tracy	San Joaquin		94,557	2.38	0.59	0.55	1.47	5.00
Yuba City	Sutter		65,324	2.52	0.76	0.30	1.43	5.01
Arden Arcade	Sacramento		107,671	2.37	0.61	0.62	1.64	5.24
Modesto	Stanislaus		213,941	2.90	0.75	0.28	1.42	5.35
Bakersfield	Kern		381,823	2.90	0.83	0.58	1.15	5.45
Turlock	Stanislaus		73,138	2.78	0.66	0.36	1.70	5.49
Stockton	San Joaquin		310,888	2.93	0.77	0.69	1.58	5.97
Fresno	Fresno		525,394	3.23	0.93	0.62	1.74	6.52
Tulare	Tulare		65,128	3.15	0.87	0.42	2.16	6.60
Merced	Merced		82,806	3.61	0.95	0.91	1.18	6.65
Madera	Madera		65,616	3.78	0.78	0.77	1.38	6.71

Appendix 5. COVID SVI of Cities in the Inland Empire Region

City	County	IH	Population	Social	Household	Minority	Housing	COVID SVI
Temecula	Riverside	Y	113,686	1.34	0.42	0.35	1.02	3.13
Rancho Cucamonga	San Bernardino		174,318	1.18	0.30	0.64	1.20	3.32
Chino Hills	San Bernardino		83,747	0.83	0.12	0.27	2.22	3.43
Murrieta	Riverside		115,143	1.62	0.64	0.53	0.76	3.55
Upland	San Bernadino		76,661	1.58	0.47	0.69	0.85	3.59
Redlands	San Bernardino		70,964	1.57	0.36	0.38	1.31	3.63
Chino	San Bernardino		87,608	1.89	0.41	0.48	1.36	4.13
Menifee	Riverside		93,997	2.08	0.45	0.71	1.15	4.38
Indio	Riverside		91,058	1.92	0.68	0.86	1.01	4.47
Corona	Riverside		169,063	2.07	0.59	0.72	1.41	4.78
Riverside	Riverside		328,929	2.57	0.79	0.73	1.23	5.33
Fontana	San Bernardino	Y	214,201	2.55	0.55	0.97	1.76	5.82
Ontario	San Bernardino		184,564	2.63	0.60	0.67	1.99	5.89
Lake Elsinore	Riverside		68,797	2.55	0.88	0.76	1.70	5.90
Apple Valley	San Bernardino		73,033	3.12	0.40	0.48	2.17	6.17
Hesperia	San Bernardino		95,538	3.44	0.92	0.36	1.92	6.64
Jurupa Valley	Riverside		108,894	3.36	0.91	0.90	1.87	7.04
Hemet	Riverside		84,789	3.48	0.89	0.57	2.13	7.07
Perris	Riverside		79,141	3.34	0.94	0.98	1.86	7.12
Rialto	San Bernardino		103,337	3.42	0.99	0.73	2.06	7.20
Moreno Valley	Riverside		212,748	3.19	0.94	0.94	2.43	7.51
Victorville	San Bernardino		118,222	3.57	0.99	0.83	2.13	7.52
San Bernardino	San Bernardino		206,957	3.53	0.96	0.85	2.38	7.71

Appendix 6. COVID SVI of Other Cities in California

City	County	IH	Population	Social	Household	Minority	Housing	COVID SVI
Thousand Oaks	Ventura	Y	126,446	0.78	0.29	0.08	1.57	2.73
San Buenaventura	Ventura		107,860	1.69	0.39	0.18	0.59	2.85
Santa Cruz	Santa Cruz	Y	64,267	1.26	0.22	0.37	1.13	2.99
Simi Valley	Ventura		125,345	1.00	0.36	0.17	1.80	3.33
Camarillo	Ventura		69,220	1.20	0.24	0.12	1.91	3.48
Santa Barbara	Santa Barbara		90,906	2.40	0.62	0.34	1.27	4.63
Santa Maria	Santa Barbara		106,388	3.17	0.98	0.25	1.87	6.27
Oxnard	Ventura	Y	207,928	3.08	0.84	0.32	2.10	6.34
Salinas	Monterey	Y	154,754	2.94	0.73	1.00	2.38	7.06

The county of Santa Barbara, Santa Cruz, and Monterey have countywide IH programs.