The Spatial Correlation between the Spread of COVID-19 and Vulnerable Urban Areas in Santiago de Chile

José Francisco Vergara-Perucich (corresponding author)

Centro Producción del Espacio, Universidad de Las Américas
jvergara@udla.cl

Juan Correa-Parra

Centro Producción del Espacio, Universidad de Las Américas
juan.correaparra1@gmail.com

Carlos Aguirre-Nuñez

Escuela de Construcción, Universidad de Las Américas
jvergara@udla.cl

Abstract: *This article identifies the spatial correlation between the social determinants of health in the housing area (housing prices, overcrowding, poor-quality building materials, and household socioeconomic vulnerability) and the spread of COVID-19 in Santiago de Chile. The research used data from the 2017 Census conducted by the National Institute of Statistics of Chile and data on confirmed cases of COVID-19 (PCR) by communes provided by/obtained from Chile's Ministry of Health. The article provides a two-fold examination/analysis of the spatial correlation using the Pearson measure to observe how the virus spread from areas with high-quality housing in the early stage of the contagion to then become concentrated in areas with low-quality of housing. The second examination/analysis is a multiple linear regression to identify the housing factors that inform virus propagation. The test results show that of the four social determinants of health relating to housing assessed here, housing prices is the variable that best predicts how the social determinants of health based on housing explain the progress of the pandemic for the Santiago case, following the collinearity factors according to the data used in this study. The conclusions suggest that public policy should treat housing quality as a factor in public health and health risks that needs to be addressed with a transdisciplinary approach to urban planning in Chile.*

Keywords: housing in developing countries; urban policy and planning; residential context of health; housing economics.
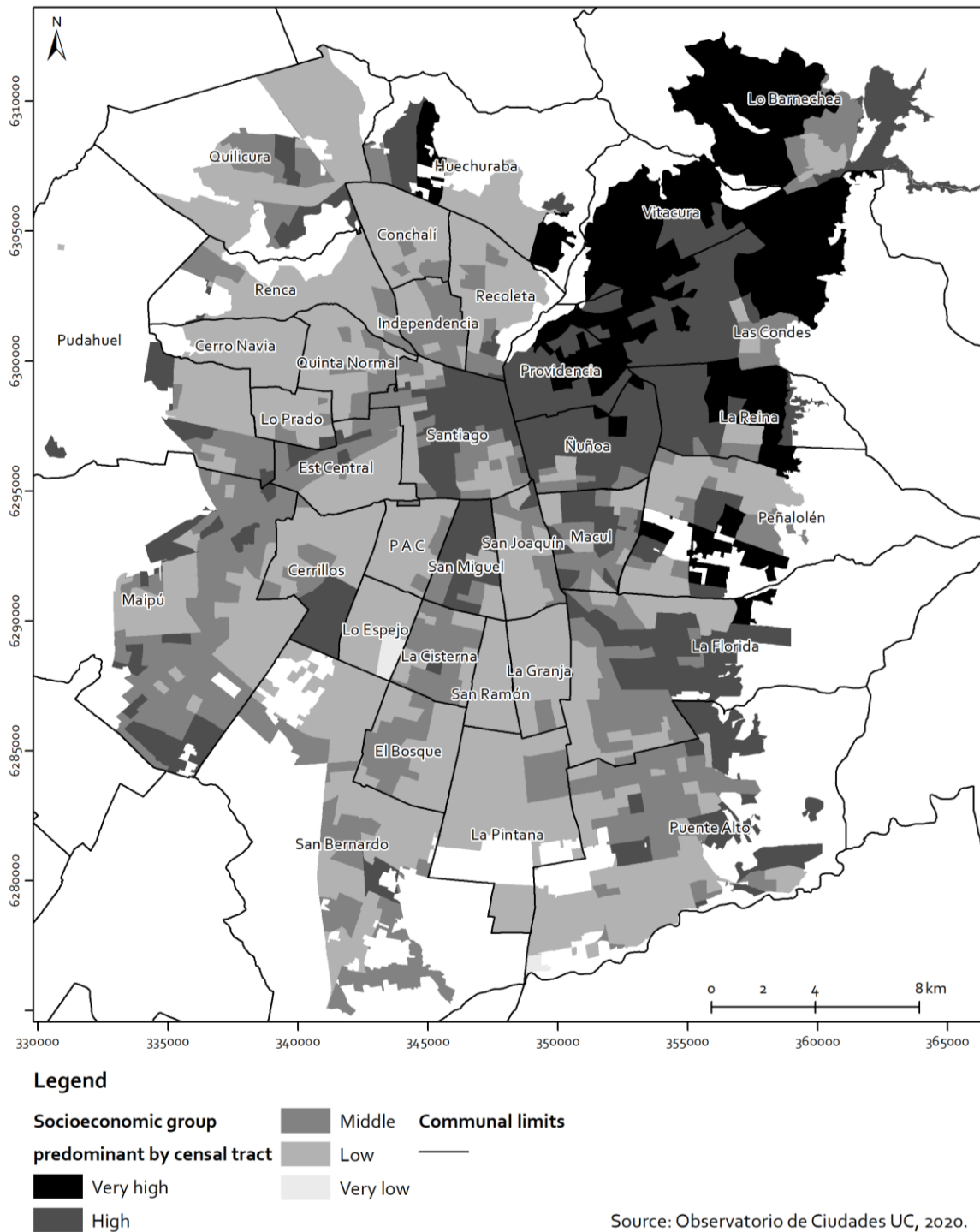
Introduction

The COVID-19 pandemic is caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and a social interaction is a main cause of contagion (Munster et al. 2020). The first outbreak was identified in the city of Wuhan in China, from where it spread over five months to reach five million people worldwide, causing over 300,000 deaths. In Latin America, the virus is already active in every nation (Johns Hopkins University 2020). It is expected to amplify socio-economic inequality in this region (CEPAL 2020) and especially to affect the most vulnerable populations, characterised by precarious jobs, low-income households, overcrowded housing, and poor living conditions that make working from home impossible (Bianchetti, Boano, and di Campi 2020; CEPAL 2020; Dávila 2020; Févre and Tacoli 2020; Ortiz and Boano 2020; Vergara-Perucich and Boano 2020). According to Annie Wilkinson, to avoid a catastrophe in sectors that are already socially vulnerable, the decisions of the authorities in managing the pandemic will be of key importance, but also crucial is understanding the pre-existing vulnerability of communities (Wilkinson 2020).

Based on data to date, this study reviews whether a relationship exists between the social determinants of health in relation to housing (World Health Organization 2013) and the increase in cases by territorial units in the city of Santiago de Chile. For the purpose of this study the social determinants of health are defined as housing prices, the socioeconomic level of households, levels of overcrowding, and the material quality of housing. These variables are tested using Pearson's correlation between them and the accumulated confirmed cases of COVID-19 for each commune between 30 March 2020 and 22 May 2020. Santiago de Chile is a metropolis composed of 34 functionally interdependent communes but with a strong axial centrality that attracts employment and commerce, making multiple daily trips towards that urban sector inevitable for most inhabitants (Hidalgo-Dattwyler et al. 2016a). In addition, the (residential) distribution of the population by commune depends strongly on household income (Vergara-Perucich 2019). For instance, the index of residential segregation measured by dissimilarity is 0.612, and the Gini coefficient of socioeconomic inequality is 0.586, which in both cases is considered very high (Rasse 2016). The interdependence of communes forces lower-income households to travel to the axial centrality from the peripheries (Figure 1), and the socioeconomic conditions in homes make voluntary confinement difficult. A city-wide quarantine was only introduced in the first week of May 2020, so while the first COVID-19 cases were located in the high-income sectors, over two months the sources of greater infection became located in the lower-income city sectors.

Figure 1: A map of socioeconomic distribution of the Santiago Metropolitan Area. The centre marks the axial centrality that attracts most daily trips into the city.

Source: Authors based on the National Census 2017.

The results of this study provide data that can be used to develop prevention plans for human disaster risks with an emphasis on health aspects (Albris, Lauta, and Raju 2020; Rom, Cadag, and Gaillard 2011). Given that the coronavirus pandemic threat meets all the conditions for applying a set of urban planning initiatives potentially leading to an effective reduction of the

contagion risk (Thomson Reuters Foundation 2020), this article seeks to produce an interdisciplinary understanding of the problem, wherein urban planners also have an important role to play in planning measures to mitigate the effect of contagion. Based on the results of the analysis, we argue that in segregated cities the disposable housing income is a key predictor of the spread of outbreaks. This implies that ensuring access to proper accommodation on a universal basis may be fundamental not only as a socio-economic measure but also as a public-health mechanism to prevent the spread of health risks in cities that will help reduce public-health risk in cities. The findings are also an invitation to the Chilean authorities to improve the urban planning apparatus moving forward and incorporating health as a key aspect of planning, one much more important than the current approach based on profit-driven urban planning. In the near future, urban planning must embrace a transdisciplinary approach to tackle the challenge ahead in a post-COVID-19 urbanism.

Materials and Methods

The study uses data from the CENSUS 2017 carried out by Chile's National Institute of Statistics. This demographic tool incorporates cartographic material on different scales. For this study, census data were used at the level of *Zonas censales (census tracts)*, which are the equivalent of a neighbourhood comprising a set of residential blocks, using which it was possible to create working samples of sensitive populations, while protecting case locations. The resulting values were indexed as part of the commune as the spatial units, a level that provides a more detailed view of COVID-19 cases. These data were obtained from the Ministry of Health, which delivers epidemiological reports with commune-level data every 3 to 4 days. The study data are provided as an annex to this article in a summary table.

This is a quantitative study of an inductive and exploratory nature (May 2001). The case is composed from 34 communes of the Santiago Metropolitan Area, taking as a reference the following variables:

Table 1: Variables and their descriptive statistics

Variables	Mean	Range	Minimum	Maximum	Standard Deviation	Variance
Housing prices	50.31	168.09	16.71	184.79	37.73	1423.28
Poor quality material housing	1357.19	3699.30	23.30	3722.60	896.97	804557.11
Overcrowding	3949.50	14170	201	14371	2878.65	8286655.11
Household socioeconomic vulnerability	12029.35	37943	535	38478	8415.78	70825404.60

Source: Authors' calculations.

A correlation study was applied to these variables comparing the number of cases per commune from 30 March 2020 to 22 May 2020. The study examines how the first COVID-19 infected people in the Santiago Metropolitan Area were located in high-income communes (Las Condes, Vitacura, and Providencia, mainly), but as it spread it advanced more aggressively to low-income communes (Puente Alto, La Florida, Recoleta, Maipú, and Independencia). With correlations between the confirmed quantity of cases by commune and study variables, a
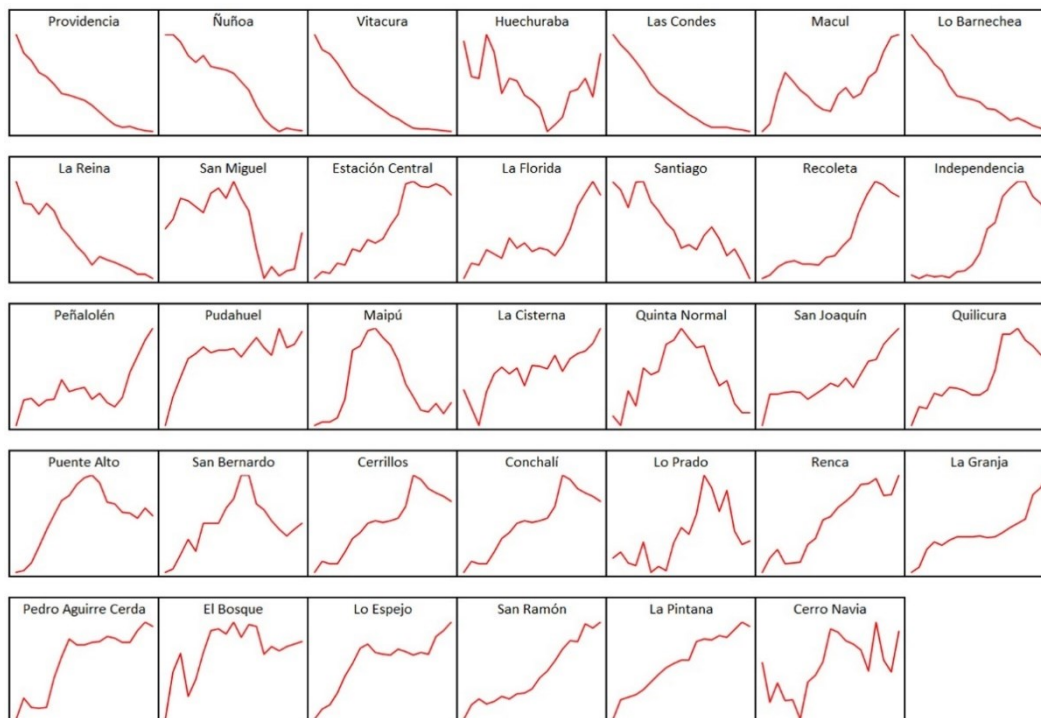
synthesis of findings is presented as a set of charts, maps, and tables synthesising the correlation between variables.

The analysis was conducted using SPSS 22 software to perform a set of Pearson correlations by date with a multiple linear regression. The map shows the spatial distribution records of accumulated cases for four significant expansion moments, in a set of maps developed using ARCGIS 10.5 software. Finally, a multiple linear regression model is developed that takes the increase of cases per commune between 30 March 2020 and 22 May 2020 as a dependent variable, and using independent variables of overcrowding, precariousness of housing, educational level of household heads, and housing prices. The objective of the regression is to identify which of the evaluated socio-spatial variables tested in this study could better explain the increase in cases from a statistical perspective.

Results

Our first analysis of our groups of variables indicates that at the start of the contagion the concentration of COVID-19 cases was located in the communes with the highest income levels: Providencia, Las Condes, Vitacura, Lo Barnechea, and Ñuñoa. However, as days passed, contagions began to concentrate in communes predominated by lower-value/lower-quality housing/lower-income households, as illustrated in Figures 2 and 3. In this initial examination we were able to identify the number of infections in each commune as a share of the total number of cases in the metropolitan area under study.
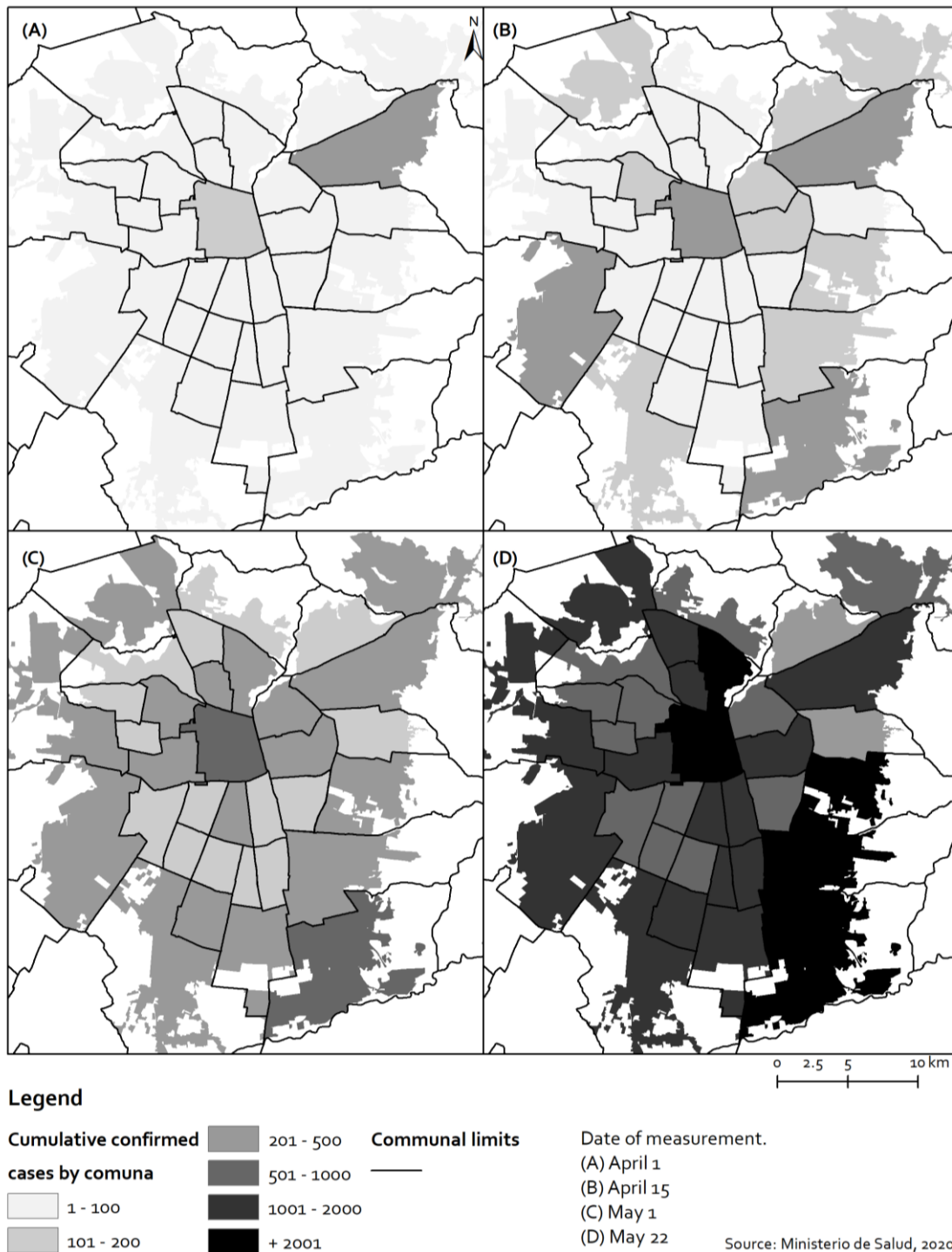
Figure 2: Concentration of cases by communes (y-axis) and their progress over time from 30 March 2020 to 22 May 2020 (x-axis)

Source: Authors' calculations based on data from the Ministry of Health of Chile.

Figure 3: Mapping diagram identifying how case concentrations moved from communes with higher socioeconomic status to those with lower socioeconomic status

Source: Authors' calculations based on data from the National Institute of Statistics and the Ministry of Health.

Using a Pearson correlation test to measure the dependence/relation between the number of cases per commune per day recorded by the Ministry of Health and the social determinants of health in the studied housing group indicated that at the start of the pandemic, in the Santiago

Metropolitan Area/when the pandemic started in the Santiago Metropolitan Area, cases were concentrated in higher-priced and higher-quality housing; however, as days passed, cases moved to communes with higher levels of overcrowding, lower-quality housing material, greater socioeconomic vulnerability, and lower housing prices, as Table 2 and Figure 4 show.
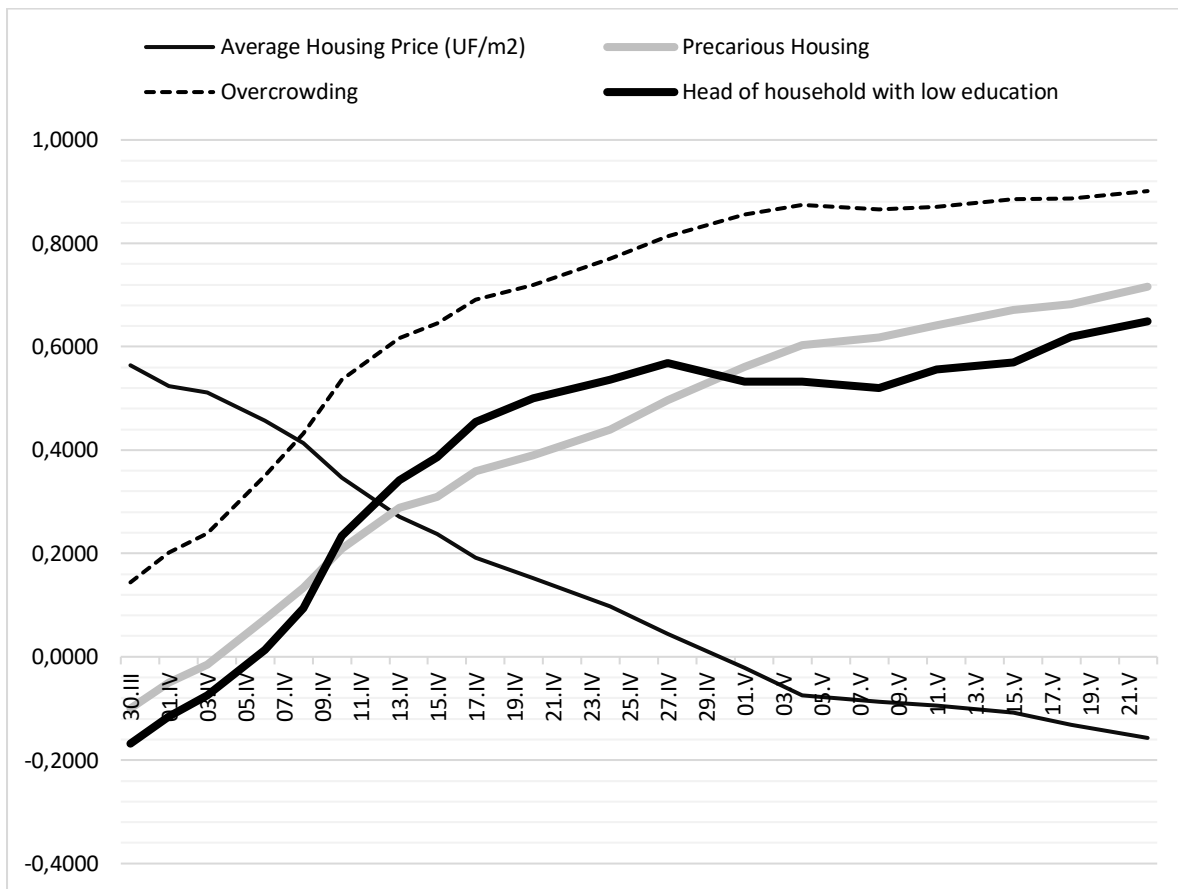
Table 2: Pearson's correlation between confirmed COVID-19 cases by commune, reported date, and social health determinants in the housing group

Accumulated cases by communes and dates	Pearson's correlation between cases by commune by date and the variables indicated				r2 adjusted model
	Housing Prices	Poor quality material housing	Overcrowding	Head of household with low education	
30/03/2020	0.564	-0.1	0.144	-0.168	0.417
01/04/2020	0.524	-0.05	0.202	-0.115	0.41
03/04/2020	0.511	-0.015	0.239	-0.074	0.428
06/04/2020	0.457	0.073	0.35	0.013	0.477
08/04/2020	0.414	0.134	0.432	0.094	0.526
10/04/2020	0.347	0.209	0.536	0.234	0.662
13/04/2020	0.271	0.288	0.617	0.341	0.703
15/04/2020	0.238	0.309	0.645	0.386	0.724
17/04/2020	0.192	0.359	0.691	0.454	0.754
20/04/2020	0.152	0.39	0.719	0.5	0.765
24/04/2020	0.098	0.44	0.77	0.536	0.808
27/04/2020	0.044	0.496	0.813	0.568	0.842
01/05/2020	-0.021	0.561	0.856	0.532	0.875
04/05/2020	-0.074	0.603	0.874	0.532	0.85
08/05/2020	-0.087	0.618	0.865	0.52	0.791
11/05/2020	-0.095	0.641	0.871	0.556	0.798
15/05/2020	-0.108	0.671	0.885	0.57	0.821
18/05/2020	-0.131	0.682	0.887	0.619	0.826
22/05/2020	-0.157	0.716	0.901	0.649	0.833

Source: Authors' calculations based on data from the National Institute of Statistics of Chile, Ministry of Health of Chile, as well as data provided by InCiti.com.

Figure 4: Graph of correlations between the variables evaluated by date and their behaviour over Greater Santiago

Source: Authors' calculations based on data from the Ministry of Health.

To determine which of the variables under study best approximated a possible statistical explanation for the increase in COVID-19 cases in different communes, we developed a multiple linear regression with the variables used in the Pearson correlation analysis in assisted entry mode using SPSS 22 software. The exploration objective was to estimate the effect of collinearity among the different variables, to identify which is the most relevant social determinant of health in relation to housing to explain COVID-19's advance in the Santiago Metropolitan Area.

Table 3: Multiple linear regression results for the study variables by input method
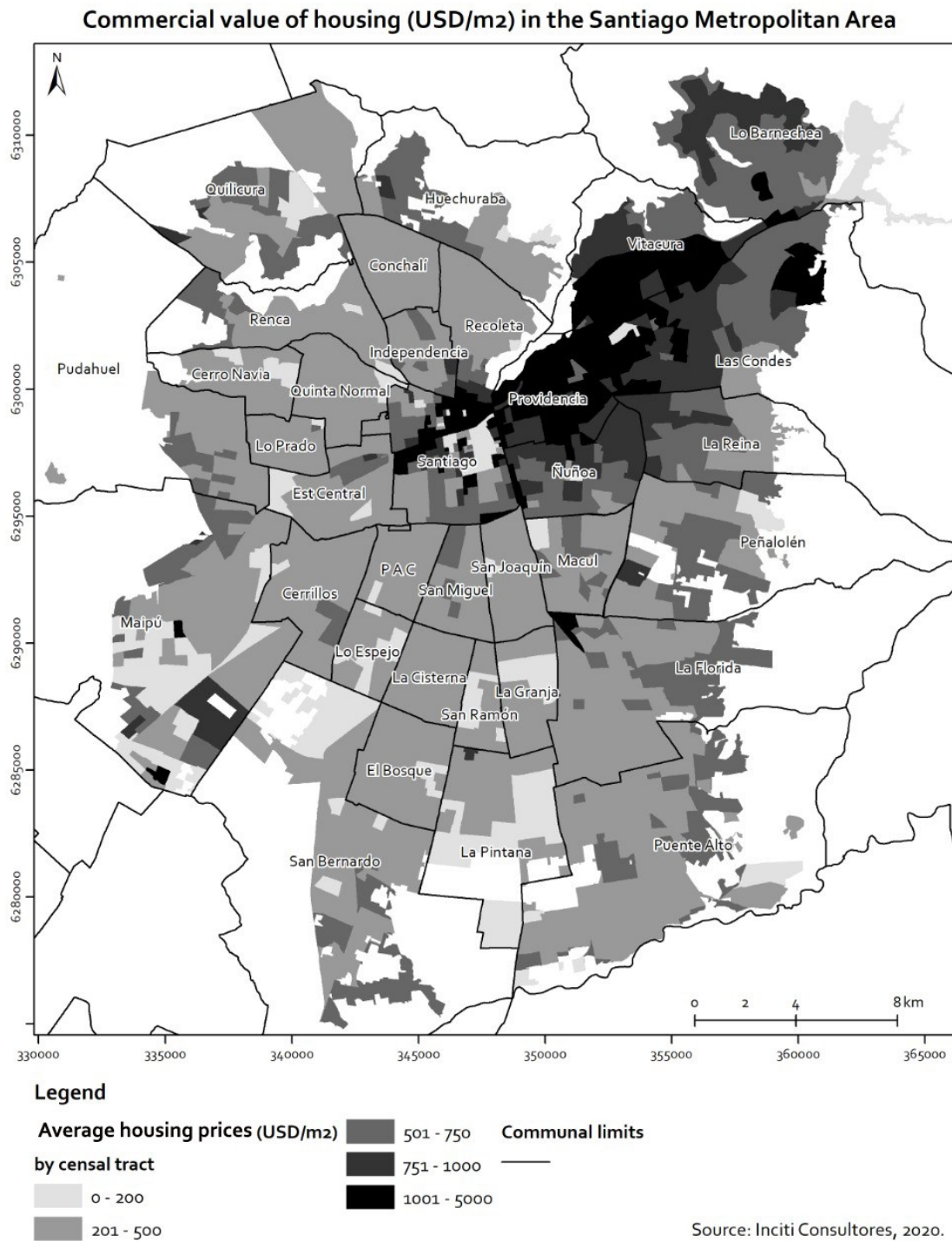
Variables	Non-standardised coefficients		Standardised Coefficients	T	Statistical multicollinearity	
	B	Standard error	Beta		Tolerance	VIF
(Constant)	111.337	29.715		3.747		
Housing prices*	**-.741**	**.287**	**-.519**	**-2.583**	**.631**	**1.585**
Poor quality material housing	.022	.019	.372	1.129	.235	4.252
Overcrowded homes	-.007	.006	-.399	-1.152	.213	4.693
Socioeconomic vulnerability	.000	.002	-.037	-.145	.386	2.588
a. Dependent variable: Increase of COVID-19 cases per commune ***Significant variable and not multicollinear**						

Source: Authors' calculations.

The results indicate that the collinearity of housing prices is the variable that best explains the increase in COVID-19 cases per commune (Figure 5). The regression results also demonstrate that the other variables were informed by housing prices as a potential valuable factor of model synthesis.

Figure 5: Average housing prices per census tract in the Santiago Metropolitan Area

Commercial value of housing (USD/m2) in the Santiago Metropolitan Area

Source: Inciti Consultores, 2020.

Source: Authors based on data from the National Institute of Statistics.

Conclusions and proposals for moving forward

The spread of COVID-19 in the Santiago Metropolitan Area followed a pattern of concentration where it moved from sectors in which the social determinants of health associated with housing were less deficient to urban sectors where housing was a complex social problem. To adequately address this issue moving forward it is necessary to turn to urban planning approaches that reduce housing material inequalities. However, in a nation where housing is allocated by a deregulated market (Toro and Orozco 2018; Vargas 2016), housing prices become a health problem for this type of critical emergency. Therefore, authorities and communities involved in housing production must consider that residential segregation increases territory health. Furthermore, housing prices qualify as a public-health issue that needs to be addressed by public policy.

The collinearity analysis indicates that in the case of the Santiago Metropolitan Area housing value is the variable that better synthesises the other factors studied in this article, which raises concerns about the neoliberal housing policies that are guiding urban development (Encinas et al. 2019; Hidalgo-Dattwyler, Bilbao, and Rivas 2016b; Vergara-Perucich and Boano 2019). We would suggest that there is a connection between housing price and crowded homes built from poor-quality materials and located in low-income neighbourhoods; therefore, household purchasing power is key for preventing the future spread of outbreaks in Chilean cities. In a city as highly segregated and inequal as Santiago, this is extremely unfair and demands a profound transformation of how proper housing solutions are found for those who cannot afford better dwellings. Another reading of this issue is that housing needs to be rethought so that it goes from being seen as a financial asset (Rolnik 2013) to a public-health component], thus changing the focus from economic development through housing production to a health planning priority to reduce public-health risks in cities. Specifically, housing must be conceived of as a human right instead of an effective source of wealth, where its role as a home and safe dwelling home ends up being neglected.

Considering that the aim of this study was to contribute to understanding the social determinants of health in a housing area, a future study could further evaluate the weight of housing prices against other factors such as morbidity, migration, daily labour travel flows, and demographic composition. Certainly, the housing price problem in the Santiago Metropolitan Area (Vergara-Perucich and Aguirre-Nuñez 2019) began before the pandemic as a result of family budgets constraints. Given that a discussion of the price of housing in Chile was already necessary for economic and humanitarian reasons before the pandemic, it is for public health reasons also necessary to discuss the viability of maintaining the existing system of allocating housing distribution in an imperfect market.

Both the pandemic and previous housing problems have revealed how important it is that Chile moves to improve its urban planning system by considering not only the physical aspects of risk associated with natural disasters but also health disasters such as that produced by COVID-19. As such, we propose that health planning should acquire a more prominent role in housing and urban planning, something that has happened in the aftermath of other epidemics and pandemics in the history of various cities (Lawson et al. 2016; Mumford 1962; Hays 2005; Perez 2016). These findings likely apply to other cities with profit-driven urban development processes, where housing allocation is defined by the break-even point of free-market economics. As a final shared reflection, the development and organisation of cities can no longer be addressed using monodisciplinary approaches. Transdisciplinarity is the key to

achieving the best solutions for the proper development of civilisation in what we hope will be post-COVID-19 urbanisms in what we hope will be the new urbanism in a post-COVID-19 era.

Acknowledgements

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