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ORIGINAL ARTICLE

The city matters: urbanization, regional analysis and urban segregation in times of the COVID-19 pandemic

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In early 2020, urban settlements worldwide have experienced the rapid expansion of severe acute respiratory syndrome (SARS-CoV-2). Cities were the hotspots of virus contamination within countries presenting significant COVID-19 notifications. In this study, we first investigate the COVID-19 dissemination between compact and sprawling big cities, examining aspects such as urban density, location of people and jobs and commuting patterns. Previous literature and recent data from three distinct big cities (New York, Los Angeles and Sao Paulo) support our discussion. Our literature review demonstrates that urban morphology, infrastructure, mobility projects and economic activities are relevant aspects of urban development that might affect interactions among citizens and COVID-19 dissemination. In addition, we show that regional scale and urban network analysis are also relevant in studies investigating COVID-19 growth. Finally, our literature review shows that urban socio-spatial vulnerability is also relevant in times of pandemic, highlighting the associations between COVID-19 dissemination and socio aspects within cities, such as poverty and inequality.

Keywords: Urbanization. Regional analysis. Urban segregation. COVID-19. Pandemic.

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Introduction

In early 2020, urban settlements worldwide have experienced the rapid expansion of severe acute respiratory syndrome (SARS-CoV-2). Cities were the hotspots of virus contamination within countries presenting significant COVID-19 notifications (VELAVAN; MEYER, 2020). Wuhan, London, New York and Sao Paulo are examples of large urban centers that recorded high numbers of COVID-19 cases (STIER *et al*., 2020; WHO, 2020). Using Lefebvre's words (LEFEBVRE, 1970), in the big city, COVID-19 imploded (densify) and exploded (horizontal spreading throughout the territory). Once virtual, the pandemic is now real.

Global statistics demonstrate variation in the intensity and speed of COVID-19 infection among countries, regions and cities (WHO, 2020). Recent literature suggests the speed of infection and spatial dispersion of the disease are related to multiple aspects: public policies (restriction of circulation and crowd sizes, dissemination of information, mass testing, immediate isolation of patients and availability of personal protective equipment) (ANDERSON *et al*., 2020); cultural aspects (SPEAKMAN, 2020); local health and hygiene conditions (WHO, 2020); epidemic timing, which penalizes areas that first presented massive cases of COVID-19; and political context (MCCLOSKEY *et al*., 2020). In addition, the territorial distribution of the population and density levels also affect COVID-19 rates (LEIVA *et al*., 2020; VELAVAN; MEYER, 2020).

Social distancing plays a critical role in controlling the dissemination of COVID-19. Therefore, different levels of social exposure cause distinct impacts on infection rates (LAU *et al*., 2020; WHO, 2020). Mathematically, the COVID-19 infection rate depends on the average number of people a sick person will infect by considering a pre-established period. Studies exploring COVID-19 dissemination find a strong positive association between its reproduction number and the socio exposure level (WU *et al*., 2020).

Urban morphology, infrastructure, mobility projects and economic activities are relevant aspects of urban development that might affect interactions among citizens (BOCAREJO *et al*., 2015). In this sense, social distancing is not exclusively related to public policies or behavioral changes, but also to the structure available and the organization of cities and rural settlements (LEIVA *et al*., 2020). Little attention has been paid in recent studies to the role urban aspects play in understanding variation in the outcome of social distancing policies. Our study helps to fill this gap by exploring COVID-19 dissemination within cities and regions by considering urban geography and urban planning frameworks.

Furthermore, the implosion and explosion of COVID-19 cases in urban areas raised multiple concerns regarding the socioeconomic and demographic dimensions of the outbreak. Different levels of poverty and inequality among neighborhoods, cities and regions worldwide are associated with the unequal availability of health resources, financial support, urban infrastructure, social assistance programs, as well as educational resources and accurate

information (VELAVAN; MEYER, 2020). Identifying socio-spatial vulnerabilities within cities and regions might support public policies seeking appropriate responses to this pandemic.

In this paper, we focus on identifying the main associations between urban aspects and the COVID-19 pandemic. We start by providing several insights on how urban form and infrastructure affect the COVID-19 dissemination, comparing epidemiological patterns between compact and sprawling big cities, as well examining aspects such as urban density, location of people and jobs, commuting patterns and the existence of vibrant public spaces. In this analysis, previous literature and recent data from three distinct big cities (New York, Los Angeles and Sao Paulo) support our discussion. Our literature review shows that regional scale and urban network analysis also matter in studies investigating the COVID-19 growth. Finally, this paper aims to investigate the urban socio-spatial vulnerability in times of pandemic, highlighting the associations between COVID-19 dissemination and social aspects within cities, such as poverty and inequality.

We built this paper based on a descriptive analytical approach and literature review, exploring the urban dimensions of the pandemic at local and regional scales. We build a dialogue between classical literature and recent urban studies, creating arguments and hypotheses associating urbanization and COVID-19. In this study, we identify three main questions: 1) Can distinct urban forms and mobility patterns at the local and regional levels affect COVID-19 dissemination in territory, and if so, what are the main aspects we should consider in policy-making design? 2) Are scale and urban networks relevant for studies investigating COVID-19 dissemination within cities and regions? 3) How can poverty, inequality and socio-spatial segregation affect the city's response to COVID-19? Instead of producing definitive answers, our insights about these questions help us demonstrate why "the city matters" when investigating the central aspects of this COVID-19 pandemic. Exploring these questions also help us to find relevant pathways for further studies exploring in some detail the urban dimensions of the COVID-19 pandemic. Finally, we built a didactic diagram summarizing the main elements associating multiscale urban aspects and the socioeconomic and demographic context with COVID-19 dissemination as well as the response capacity of urban societies to pandemics.

Urban geography, mobility and COVID-19: investigating New York, Los Angeles and Sao Paulo

Proximity and density are fundamental aspects of the establishment, development and growth of cities in history (SCOTT; STORPER, 2015). In our contemporary metropolis, or postmetropolis, the high concentration of people, economic activities and social relations is the summit of *synekism*, or the impetus for development derived from urban agglomeration (SOJA, 2000). In addition, Jacobs (1961) considers that the stimulus of urban agglomeration is the spark of economic life of cities. Intrinsic geographical characteristics

(proximity, density and agglomeration) make cities thrive and, at the same time, increase urban vulnerability to pandemics.

Cities worldwide present distinct urban form and structure. Analyzing these two aspects, we find a set of compact cities, such as New York, San Francisco and Tokyo, as well as sprawling cities, such as Los Angeles, Atlanta and Sao Paulo (JENKS; BURGESS, 2001). In general, compact cities require intensive land use and high-density urban settlements, which make it possible to shorten distances between people and opportunities, such as jobs, educational resources and cultural attractions (ABDULLAHI *et al*., 2017; BURTON *et al*., 1996; OECD, 2018). In contrast, urban sprawl involves residential or commercial projects in locations distant from existing urban areas, creating suburbs and changing commuting patterns, which undermines the cost-benefit of public services by creating an inefficient, uncoordinated and automobile-dependent environment (EWING *et al*., 2003).

Mobility is at the heart of the problematic between compact and sprawling cities. In general, compact cities derive strength from active and collective transport while creating places of encounter for citizens. In contrast, urban sprawl increases daily travel distance by requiring the intensification of private mobility (BANISTER, 2012). Urban sprawl stimulates the automobile industry and requires public and private investments in roads and highway networks, which increases air pollution within cities and regions (ABDULLAHI *et al*., 2017; NOZZI, 2003).

Both city models shape life style and behaviors of people, by concretely affecting everyday life (SOJA, 2000). Mouratidis (2019) highlights the synergies between compact development and human well-being by showing that compact cities can be beneficial for social relationships, by increasing the frequency of socializing as well as the opportunity of making new acquaintances. In general, compact cities are walkable while cars dominate low-density areas created by urban sprawl (EWING *et al*., 2003).

In the real world, there are interactions between both models through space and time. In literature, we find several examples of cities that present most of the characteristics listed in these pure state representations. The compact New York and the extended Los Angeles and Sao Paulo serve as classic examples in studies exploring the peculiarities and differences between compact and sprawling cities (e.g. DIELEMAN; WEGENER, 2004; SOJA, 2000). These characteristics (compactness and sprawling) are not captured by only observing the overall density in these urban settlements, since variations in the denominator (area) and distinct center-periphery dynamisms must be taken into account.

Leiva *et al*. (2020) presented a comparative study considering New York, Los Angeles and Sao Paulo, exploring aspects related to COVID-19 dissemination, urban form (compactness and sprawl development) and transport structure. In this section, we seek to investigate these cities in some detail, expanding the period of analysis (February to October 2020) and providing new arguments supporting the main findings presented by the authors. This exercise successfully demonstrates the relevance of intra urban aspects in studies investigating the COVID-19 dissemination within cities and territories.

Considering official administrative boundaries, New York City hosts 8.38 million people distributed over 784 km² (10,702 people/km²) while Los Angeles presents 3.99 million people over 1,210 km² (3,298 people/km²) (U.S. CENSUS BUREAU, 2018). In addition, Sao Paulo is the largest urban agglomeration of South America, hosting 11.25 million people distributed over 1,521 km² (7,398 people/km²) (IBGE, 2010). Moreover, the New York Metropolitan area hosts 19.2 million people over 6,685 km² (2,875 people/km²), while the Los Angeles metropolitan area presents 13.35 million people over a larger area (12,562 km²). Therefore, population density in the Los Angeles metropolitan area (1,063 km²) is significantly lower than in New York. In Sao Paulo, the metropolitan region hosts a huge population (21 million people) over 7,946.96 km² (2,643 people/km²). In addition, Florczyk *et al*. (2019) built a dataset considering distinct unit areas within urban agglomerations throughout the world. In this database, the urban agglomeration comprising New York-Newark hosts 15.95 million people distributed over 5,384 km² (2,963 people/km²) while the Los Angeles/Long Beach/Santa Ana areas exhibits 14.28 million people over 5,633 km² (2,535 people/km²). The mapped area within the Sao Paulo metropolitan region considers 19.11 million people over 2005 km² (9,533 people/km²). These databases show that working with general density can be ambiguous, although these data are still relevant in urban analysis. It demonstrates that the New York urban area is denser than Los Angeles and Sao Paulo by considering these three units of analysis. In our descriptive analysis, we use the official administrative boundaries as a reference to delimit the main city (the municipality of Sao Paulo and the cities of New York and Los Angeles) and the metropolitan region.

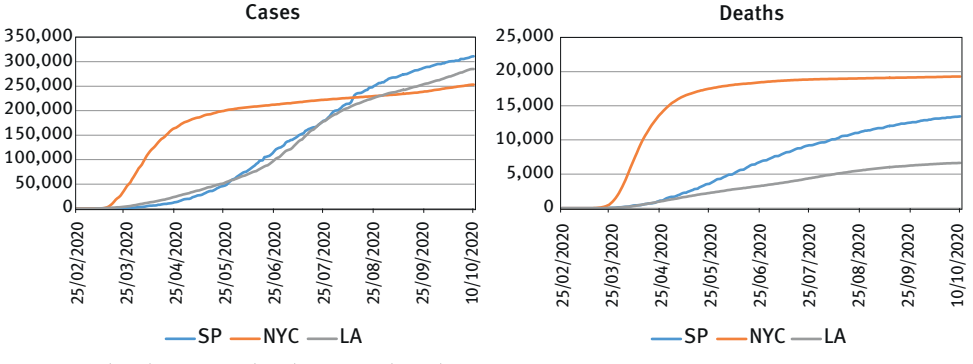
The population living in these three urban agglomerations have different age structures. Since COVID-19 has different effects by age, causing greater complications for the elderly population (WHO, 2020), understanding differences in the age structure of populations is relevant. According to Table 1, New York has the highest percentage of people aged 60 years and over (21.13% and 20.62% in the city and metropolitan area, respectively), which increased the population's vulnerability and the pressure on the health system in the first weeks of the pandemic. Los Angeles has a younger age structure compared to New York, with fewer seniors (18.31% and 19.97% in the city and metropolitan area, respectively) and more adults (64.79% and 62.28% in the city and metropolitan area, respectively). Sao Paulo has the highest percentage of adults among cities, while it has the lowest proportion of elderly people (11.91% and 11.56% in the city and metropolitan area, respectively).

New York, Los Angeles and Sao Paulo were significantly affected by the COVID-19, which demanded implementation of social distancing measures. In this paper, we explore epidemiological data between February 25, 2020 and October 10, 2020, considering the pre-vaccination period. According to Figure 1, New York recorded an extremely high number of cases and deaths between March and April. In New York, the epidemiological curves were flattened since early June. In contrast, Los Angeles and Sao Paulo did not present an explosion of cases and deaths during the first months of the pandemic. Instead, these cities showed a slow growth of cases between March and April, considerably increasing

since May and overtaking New York in August. New York presented a high number of total deaths by October 25 (19,278), since the pandemic strongly disseminated within the city in the first months, when the epidemiological knowledge of COVID-19 was relatively low. The higher number of deaths in Sao Paulo than in Los Angeles suggested that cities worldwide present different capacities to deal with pandemics appropriately. When considering the standardized data to population, Figure 2 shows that contamination and deaths in New York were still relevant during the first months. The high number of deaths (per 100,000 people) recorded in New York between March and May reflects poor medical knowledge about COVID-19 (WHO, 2020) and a high concentration of recorded cases in the early stages. In Los Angeles, the total cases per 100,000 people were significantly higher than in New York and Sao Paulo during the last assessed months. In addition, Sao Paulo has presented the lowest figures when standardizing to population.

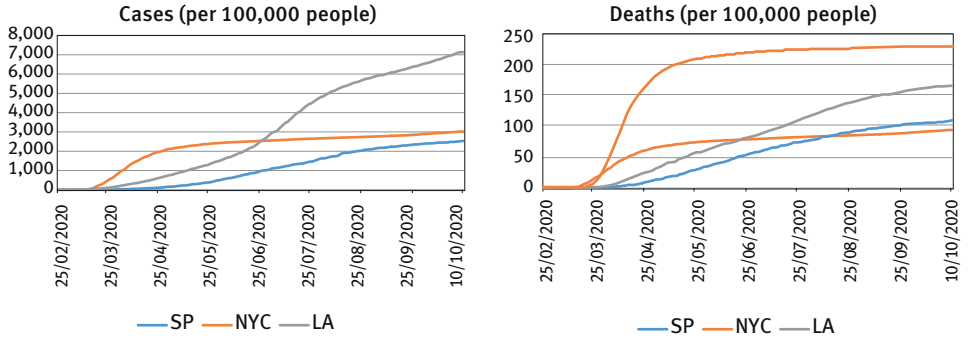
These data were released by official sources, which show different levels of underreporting between cities and countries. Estimates of underreporting of deaths by COVID-19 are more accurate than estimates of infection, given the existence of consistent historical series of mortality in Brazil and the United States (ALVES *et al*., 2020). In a report compiled by Marinho *et al*. (2020), the increase in the excess of deaths from natural causes accompanied the increase in records of deaths by COVID-19 in Brazil and in several other countries around the world, indicating the existence of underreporting of mortality associated with the pandemic. In the United States, Whittaker *et al*. (2021) reveal that official statistics undercount the correct number of COVID-19 deaths in the country. According to recent studies, underreporting for Brazil (24.6%) (MARINHO *et al*., 2020) and the United States (24%) are at similar levels (IULIANO *et al*., 2021). In addition, even official records can show differences in the number of deaths. As an example, the current New York State Administration reported differing mortality figures from the previous administration, adding 12,000 more deaths from COVID-19 to the record (KRAMER, 2021). Therefore, ongoing reviews of official records based on estimates must be made, whether at national, state or local levels.

FIGURE 1
Total recorded COVID-19 cases and deaths
Sao Paulo, New York City and Los Angeles County – February 25, 2020-October 10, 2020



Source: IHME (2020), NYC Health (2020), Sao Paulo (2020a).

FIGURE 2
Total recorded COVID-19 cases and deaths per 100,000 people
Sao Paulo, New York City and Los Angeles County – February 25, 2020-October 10, 2020



Source: IHME (2020), NYC Health (2020), Sao Paulo (2020a).

Although cities present confounding effects arising from the multiple factors associated with virus dissemination, such as efficiency of policies, population engagement and the pandemic's timing, the analysis of urban form, structure and organization may raise relevant elements for our discussion. In addition, studies associating COVID-19 and urban aspects must consider not only the main city but also the metropolitan area. In these approaches, both units of analysis matter. First, exploring the core of the metropolitan region can place the focus where urban life is stronger given the usual high concentration of people, social interactions, public spaces, cultural life, buildings, services and economic activities. According to Table 1, the core areas presented high COVID-19 rates (per 100,000 inhabitants) than their respective metropolitan regions. In addition, core municipalities within metropolitan regions usually have administrative autonomy. Public policies are often designed and implemented in these areas by researchers and local authorities without necessarily being followed by neighboring administrations. On the other hand, assessing metropolitan areas is very relevant during pandemics. Integrated problems in dense integrated regions require integrated initiatives among local authorities. Therefore, public policies must consider the metropolitan regions when addressing COVID-19 dissemination within large urban areas.

Recent studies suggest that the intensive use of walkable public spaces in the compact cities might affect COVID-19 dissemination (LEIVA *et al*., 2020; STIER *et al*., 2020). In New York, urban planning considered the design of vibrant walkable public spaces by creating a pedestrian-friendly environment in the city. In New York, 49% of the city is occupied by public areas, such as sidewalks, streets, parks and squares (CARMONA *et al*., 2004). Furthermore, NYC (2003) demonstrates that New York exhibit a high proportion of buildings presenting an active design, which increases the interaction between public and private spaces and encourages the occupation of sidewalks by pedestrians. Therefore, Leiva *et al*. (2020) argued that these characteristics may contribute to decrease the daily physical and social distancing levels in New York, which probably increased the COVID-19 dissemination

in the pre-lockdown period. In contrast, the sprawled Los Angeles presents clusters of walkable spaces in some commercial areas, such as Downtown, Westwood and Koreatown. These centralities of Los Angeles exhibit a significantly lower demographic density than the more populated areas of New York (FRASER *et al*., 2017).

Data provided by Walk Score (2020) reveal relevant differences in walkability between the compact New York and the sprawled Los Angeles. The Walk Score measures the walkability of residents to nearby amenities based on multiple data: Google, Factual, Great Schools, Open Street Map, the U.S. Census, Localeze, and places added by the Walk Score user community. The Walk Score is a reliable tool for measuring the walkability of a specific area since data from most of these sources are frequently reviewed and updated, which makes the Walk Score more accurate than other tools (CARR *et al*., 2010, 2011; GILDERBLOOM *et al*., 2015). The Walk Score method uses geo-location to combine land use mix, population density and street grid density. This score measures walkability on a scale from 0 to 100 by assessing walking routes from home to grocery stores, schools, parks restaurants and retail.

The Walk Score in New York City (88) is significantly higher than in Los Angeles (68). According to the Walk Score initiative, most errands might be accomplished on foot in New York, while only some errands might be accomplished on foot in Los Angeles. Furthermore, the Walk Score initiative also provides complementary scores, such as the transit score and the bike score. The transit score measures how well the city is served by public transport, while bike score measures the city's suitability for biking. New York also presents higher transit score (84), reflecting its extensive bus and subway systems, and bike score (70) than Los Angeles (53 and 59, respectively) (WALK SCORE, 2020). These scores reflect distinct urban structures (such as transport and services) and morphologies exhibited by New York and Los Angeles, helping researchers investigating compact and sprawling development. Measuring empirical manifestations of the main urban aspects presented by these city model's, such as walkability, can support studies exploring urbanization, social development and COVID-19 dissemination within cities. However, according to Ribeiro e Sousa (2019), the Walk Score dos not consider some factors, such as the existence of sidewalks, afforestation, cleanliness and safety, which restricts some interesting analytical possibilities.

It is not possible to find measurements performed by Walk Score for Sao Paulo. Other walkability indicators, such as Walkonomics, Walkability Asia, Walk & the City, Walkability Mobile App, Rate my Street and Global Walkability Index, can be used to complement studies on the topic (RIBEIRO; SOUSA, 2019). None of these initiatives considers the construction of measures for Sao Paulo. In addition, there are ideas under development that could be launched in the next few years, such as the app developed by the walk21 initiative (WALK21, 2021). Moreover, the study developed by Rede Nossa Sao Paulo (2019) demonstrates the existence of relevant restrictions in the urban structure that affect walkability in the city. Based on 800 interviews in five regions of Sao Paulo city, the survey registered the dissatisfaction of pedestrians with the sidewalks, mainly due to potholes

(68% of respondents), irregularities (53%) and width (47%). Problems with security (39%) and lighting (39%) are also recurrent complaints. Most respondents walk in the city just to access very essential services, such as bakery (67%), market (64%), bus stop (61%) and pharmacy (59%), essential activities for survival, such as work (11%) and school/course/university (18%), and access to cultural facilities (8%) but usually do not encourage walk commuting. This research does not include peripheral cities of the metropolitan region, where the greater distances in relation to the consolidated center and sub centers and the safety and infrastructure conditions, as shown by Villaça (2011), probably significantly compromise walkability in these areas.

The compact New York includes well-structured public transport systems, such as the subway and bus lines. In New York, the subway is the most attractive mass transportation (FREY, 1999). In contrast, cars are discouraged within the city by the high costs of parking and toll, especially in Manhattan (PANYNJ, 2021). Reflecting on daily social distancing in subways, Leiva *et al*. (2020) shed light on the awarded play called *Dutchman*, written by Amiri Baraka. This play highlights the spatial opportunity for repetitive observation and social interaction in the New York Subway (BARAKA, 1964). As stated by Leiva *et al*. (2020), subways generally promote large agglomerations of people from different locations, by decreasing the daily level of social distancing in the urban environment. Recent figures show that the New York subway registered 1.757 billion individual trips in 2016 connecting Manhattan to other boroughs (Bronx, Brooklyn, Queens e Staten Island) (NYC, 2016).

Public transport can affect COVID-19 dissemination within cities, metropolitan areas and urban networks (ECDC, 2020; YANG *et al*., 2012). According to the European Center for Disease Prevention and Control (ECDE), there are two main risks associating COVID-19 dissemination and public transport: 1) crowding in subways or buses can increase direct (respiratory droplets) and indirect (contaminated surfaces) COVID-19 transmission; 2) public transport staff are at risk given the high levels of contamination in crowded areas. Although the epidemiologic risks of transmission of respiratory diseases in the bus lines are significant (YANG *et al*., 2012), the potential COVID-19 contamination rates within subways are higher because this mass transport mode is generally projected to follow routes crossing highly dense areas (HARRIS, 2020).

In contrast, the urban form and structure of Los Angeles are based on the intensive use of cars and buses. Public areas were designed preferentially to support the circulation of motor vehicles, which hinders active transport within the city (LEIVA *et al*., 2020). In general, the intensive use of private transport to access the main center and sub centers from large residential areas constrains vibrant public spaces for permanence and coexistence in the city (OECD, 2018; SOJA, 1996, 2000). According to Tomtom International traffic index 2019 (TOMTOM, 2019), Los Angeles is the most congested city in United States by presenting the highest traffic index (42%) in 2019, while the compact New York exhibited a lower figure (37%).

In general, the number of daily public transport users in Los Angeles (176,672 and 309,975 people within the core city and the metropolitan area, respectively) is significantly

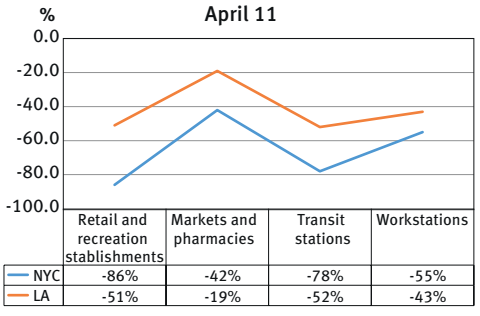
lower than in New York (2,229,452 and 2,970,634 people, respectively) and Sao Paulo (2,526,398 and 3,910,029 people, respectively). Considering the daily public transport users in these cities by taking into account their respective population stocks, Los Angeles city and its entire metropolitan area present very low figures. While daily public transport users in Los Angeles correspond to 4% (within the city) and 2% (within the metropolitan area), these figures are significantly higher in New York (27% and 15%, respectively) and Sao Paulo (22% and 19%, respectively). This low number of people using public transport in Los Angeles is certainly associated with sprawling development, urban structure and local socioeconomic levels.

In Los Angeles, the subway articulates the central area with a low-density periphery. According to Table 1, the city registered 26,677 daily individual subway trips in 2019, 45.2 times lower than the New York figures. The high distances involving commutes between suburbs and center areas make the bus a less attractive option compared to private transport within a sprawling developed urban area, especially when most of households in the suburbs present cars.

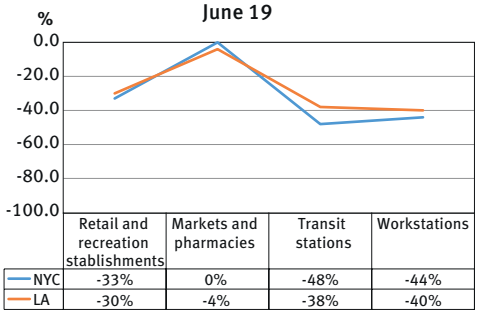
Only 12.2% of households in Los Angeles did not present cars in 2018 (U.S. CENSUS BUREAU, 2018). In contrast, 54.5% of households in New York City consisted of people with no cars (NYCEDC, 2018). During a pandemic, cars are a relatively safe environment compared to public transport, such as subways and buses. The risk of contamination by COVID-19 on route is much lower in private transport than in public mass transport (TCHIR, 2020).

In addition, Leiva *et al*. (2020) identified significant changes in intra-mobility patterns within New York and Los Angeles using Google data due to the adoption of social distancing policies during this pandemic. Here, we updated these data by considering two dates: April 11, 2020 and June 19, 2020. Google data show changes in mobility by mapping some predetermined destinations, such as retail and recreation, grocery and pharmacy, transit stations and workplaces. On April 11 and June 19, mobility reduction in New York was higher than in Los Angeles, considering the baseline (median value between January 3 and February 6, 2020). On April 11, New York presented a higher reduction in daily movements destined to retail and recreation establishments (-86%, against -51% in Los Angeles), markets and pharmacies (-42%, against -19% in Los Angeles), transit stations (-78%, against -52% in Los Angeles) and workplaces (-55%, against -43% In Los Angeles). On June 19, the differences between New York and Los Angeles decreased in the assessed destinations: retail and recreation (-33% in New York, against -30% in Los Angeles); grocery and pharmacy (0% in New York, against -4% in Los Angeles); transit stations (-48% in New York, against -38% in Los Angeles); workplaces (-44% in New York, against -40% in Los Angeles) (Figure 3).

FIGURE 3
Intra-mobility changes according to Google Data
New York City and Los Angeles – April 11, 2020-June 19, 2020



	Retail and recreation stablishments	Markets and pharmacies	Transit stations	Workstations
NYC	-86%	-42%	-78%	-55%
LA	-51%	-19%	-52%	-43%



	Retail and recreation stablishments	Markets and pharmacies	Transit stations	Workstations
NYC	-33%	0%	-48%	-44%
LA	-30%	-4%	-38%	-40%

Source: Google (2020).

Thus, the data from April 11 suggest that social distancing policies were more severe in New York than in Los Angeles. Probably, the timing and severity of COVID-19 dissemination in New York during the first half of April 2020 have significantly contributed to increase the caution of local authorities. In contrast, further studies might investigate if sprawling development and the automobile-based transportation system in Los Angeles have increased the city's resilience to pandemics, by allowing higher levels of internal socioeconomic dynamism and mobility and thus avoiding the explosion of COVID-19 recorded cases. However, Figure 1 shows that the curve in Los Angeles did not get flat after the first months of the pandemic, which suggests that social distancing policies and behavior changes in this large sprawling city were less effective when compared to other cities, such as New York and Wuhan. Further studies can investigate in some detail whether the feeling of security attributed to lower density spaces in most of centers and subcenters in the sprawling Los Angeles, compared to Manhattan and to the relatively lower daily COVID-19 figures considering the New York City figures, can produce worse long-term outcomes. The data presented in Figure 1 as well as the mobility patterns revealed by Google data suggest that this is a plausible hypothesis.

In developing countries, we must consider the specificities in demography, urban form and transport system presented by big cities. The city of Sao Paulo has a significantly larger population stock than New York and Los Angeles, which makes combating the pandemic more challenging. Sao Paulo presents a greater diversity of urban forms in the suburbs compared to large cities from developed countries, such as New York and Los Angeles. The Sao Paulo suburbs present gated communities and high and medium-income neighborhoods, as well as extensive informal and poor settlements (VILLAÇA, 2011).

The city of Sao Paulo had 6.2 million cars and 961.686 motorcycles in 2019 (DENATRAN, 2018). Sao Paulo's buses (1.4 million individual trips per day in the core municipality and 2.3 million daily individual trips within the entire metropolitan region) and subways (848 thousand daily individual trips in the core municipality and 1.1 million daily individual

trips within the metropolitan region) are mostly used by the low-income population (SÃO PAULO, 2018), while New York's public transport includes residents from various social strata (ROSEN, 2010). In January 2018, 80.74% of public transport users earned less than the Brazilian minimal wage ($ 3.04 U.S. dollar per day) (SÃO PAULO, 2018). In addition, while most of the Los Angeles suburban population has access to cars, in Sao Paulo, the majority of the population will face higher risks of exposure to the virus in public transport in case of commuting, which challenges the economic opening during the pandemic. Distinct segregation levels in the transport system probably affect how COVID-19 has disseminated within urban centers worldwide.

Urban geography and city planning might be associated with the rate of contamination of COVID-19, especially at the first stages of the pandemic, when local authorities had not yet adopted social distancing policies. The epidemiological and mobility data, as well as the studies presented here, suggest that cities that benefit from a more democratic urban life associated with compact development, such as New York, may be penalized compared to sprawling cities, such as Los Angeles, given the distinct use of land and aspects related to public transport and public spaces (LEIVA *et al*., 2020). In fact, New York exhibits multiple spaces suitable for human contact and, consequently, for the dissemination of COVID-19. Los Angeles, in contrast, whose sprawling development was associated with the growth in the number of automobiles, presented lower infection and mortality rates than New York in the first months of pandemic (LA, 2020). When considering the emergence of new variants, such as Omicron in late 2021, New York seems more vulnerable, especially after decreasing social distances measures (the total number of COVID-19 cases in New York City increased fast, by achieving 17.958 records in December 21 2021, which is the highest value recorded in the city since the pandemic emerged). In contrast, Los Angeles presented 3.097 cases in this same date, which is far from the highest figures recorded in the county. Once again, a "new" virus spreads faster in New York in than Los Angeles when social distancing measures are not significant.

In addition, the high levels of socio-spatial segregation in Sao Paulo delayed the significant registration of cases in the poorest peripheries, which, after a certain point, started to grow explosively in the face of the high vulnerability to the pandemic in these areas. Further studies might investigate the empirical associations among epidemiologic, mobility and urban data in some detail in order to confirm or reject the idea of compact development stimulating COVID-19 dissemination in the early stages of pandemic, when social distancing measures were not taken.

Hamidi *et al*. (2020) investigated the association between density and spread of COVID-19 in 913 U.S. metropolitan counties. The authors demonstrate that population size in metropolises is a powerful predictor of infection rates, as larger urban agglomerations have higher rates of infection and death. However, greater demographic density during the pandemic in the cities assessed meant lower mortality rates, probably due to access to better health services.

In recent work, Dhaval (2020) considers that the rapid spread of COVID-19 in big cities should be a wakeup call for urban planners and authorities to reconsider the idea that dense cities are indeed better cities. However, we should consider that keeping high-density urban spaces usually means less pressure on rural and natural environments, which could decrease the chances of triggering new outbreaks worldwide as demonstrated by Dobson *et al*. (2020). Dissolving an important democratic city project, such as New York, as a long-term response to pandemics does not seem reasonable, especially considering that humans can learn to improve management and even avoid future outbreaks. Compact cities respecting geographic, historical and architectural characteristics usually create development-friendly agglomeration economies due to the smarter distribution of people and available resources. Instead of fighting against compactness, authorities and policy makers should readdress old social demands, seeking to promote the inclusion of the most vulnerable population, thus building a more just, resilient, healthy and democratic society.

According to the latest United Nations Human Settlements Programme (UN-Habitat) report, COVID-19 does not mean the end of cities as the successful ability of dense urban settlements (such as New York) to manage the virus is encouraging (UN-HABITAT, 2000). In a recent paper, Carozzi *et al*. (2020) show that density is close related to the early arrival of COVID-19 but it is not necessarily associated to a high subsequent spread. In fact, Figure 1 and 2 demonstrated that the dense New York was seriously affected first compared to Los Angeles and Sao Paulo. Despite being a compact city presenting intense social relations, New York City, as well as the entire metropolitan area, showed that simple measures such as wearing masks and respecting social distancing help flatten the curve of infections quickly (Figure 1). In addition, preliminary studies on Sao Paulo suggest that urban form and structure, as well as household characteristics, can affect COVID-19 dissemination within large cities, especially those presenting poor social engagement and low compliance with social distancing (SÃO PAULO, 2020b; SOUSA; SANTOS, 2021).

Cities presenting extensive poor peripheries with a high proportion of residents per household will face enormous challenges in the implementation of reopening and social distancing policies. In Sao Paulo, large distances between central areas and poor residential neighborhoods require not only short-term changes in the public transport dynamics, but also a reduction in the concentration of jobs and services while creating democratic transformations on the urban form. Urban form changes might increase shorter commutes in urban areas, which makes transportation cheaper and reduces socio-spatial segregation in the city. The challenges revealed in this pandemic must trigger the reopening of old debates about demands already known (such as housing deficit, inadequate housing, excluding urban forms and socio-spatial segregation) seeking social inclusion and long-term improvements for the population. Finally, Table 1 summarizes the main variables explored in our comparative analysis of New York, Los Angeles and Sao Paulo. We must consider there are limitations in comparing sociodemographic and contamination data between different

cities, given the existence of multiple factors that can obscure the analysis. However, these basic analyses are relevant, pointing out paths for further investigations.

TABLE 1
Main variables explored in the comparative analysis
New York, Los Angeles, Sao Paulo and metropolitan areas – 2010-2020

Variables	City			Metropolitan area		
	New York	Los Angeles	Sao Paulo	New York	Los Angeles	Sao Paulo
Population (million)	8.38	3.99	11.25	19.2	13.35	21.00
Area (km²)	784	1,210	1,521	6,685	12,562	7,946.96
Density (people/km²)	10,702	3,298	7,398	2,875	1,063	2,643
% of population between 0 to 14 years	17.39	16.90	20.77	17.86	17.75	22.55
% of population between 15 to 60 years	61.48	64.79	67.33	61.52	62.28	65.89
% of population between wth 60 years or more	21.13	18.31	11.91	20.62	19.97	11.56
COVID-19 total cases (October 25, 2020)	253,192	122,481	311,116	532,385	290,467	505,002
COVID-19 total deaths (October 25, 2020)	19,278	3,028	13,431	33,641	6,721	22,565
COVID-19 total cases / 100,000 inhabitants (October 25, 2020)	3,017.78	3,069.70	2,529.40	2,772.84	2,175.78	2,389.04
COVID-19 total deaths / 100,000 inhabitants (October 25, 2020)	229.77	75.89	109.19	175.21	49.56	106.74
% of households without cars	54.5	12.12	46.62			52.57
Individual trips using public transport (daily average)	2,229,452	176,672	2,526,398	2,970,634	309,975	3,910,029
Daily transport users / population	0.27	0.04	0.22	0.15	0.02	0.19
Individual trips by subway (daily average)	1,206,134	26,677	848,537	1,607,113	46,806	1,103,023
Individual trips by bus (daily average)	655,459	118,724	1,406,705	873,366	208,303	2,356,582
Unemployed people between March and June, 2020 (thousand)	792.1	247.3	164.66	1,296	588.6	211

Source: Population, area and density (U.S. CENSUS BUREAU, 2019; IBGE, 2010); COVID-19 cases and deaths (IHME, 2020; NYC HEALTH, 2020; SÃO PAULO, 2020a); % of households with no car (IBGE, 2010; U.S. CENSUS BUREAU, 2015; NYCEDC, 2018); individual trips by public transport, subway and buses(U.S. CENSUS BUREAU, 2019; ORIGIN AND DESTINATION RESEARCH IN SAO PAULO, 2017); unemployment data (BRAZIL, 2020; U.S. CENSUS BUREAU, 2020; EDD, 2020).

Regional analysis matters: urban networks and COVID-19

Studies exploring urban networks and the regional influence of cities might be useful for policymakers examining the patterns of COVID-19 dissemination within states, provinces and countries. Regional thinking can assist scientists in estimating the growth of cases in cities polarized by centralities presenting significant levels of contamination. While classic studies by Weber (1929), Christaller (1933) and Losch (1940) demonstrated how the location of industries and services organizes the territory by creating urban networks, recent evidence suggests that analyzing cities' regions of influence might be relevant for understanding COVID-19 dissemination at the regional level. On this topic, we identified promising research pathways that can be explored in some detail by further investigations.

Epidemiological studies generally use political and administrative boundaries as a reference for the construction of units of analysis. However, the design of urban networks often overlaps state boundaries. As an example, policymakers should be aware of the spatial peculiarities of Minas Gerais state (Brazil), which neighbors the states containing the two largest cities in the country: Rio de Janeiro and Sao Paulo. Despite having a dynamic metropolitan region, Belo Horizonte (5.96 million inhabitants in 2018), medium-sized cities located close to state borders, such as Uberlandia and Juiz de Fora, have much closer intercity relations with Sao Paulo and Rio de Janeiro than with their state capital, given the geographical proximity and the development of logistical structures that support closer relationships. Thus, research exploring the regions of influence of cities in Brazil, such as the IBGE reports (2008, 2018), might be useful for the design of more appropriate space units when investigating the spatial dimensions of COVID-19.

Recent studies have investigated the geographic dispersion of COVID-19 at the regional scale by taking into account the dynamics of urban networks. Studying the bus transport networks of Beijing, Shanghai and Hangzhou, Yang *et al*. (2012) confirm that mobility affects the dissemination patterns of infectious diseases in these territories. In addition, Zheng *et al*. (2020) evaluated the role of intercity transport in disseminating COVID-19 through buses and trains from Wuhan to surrounding cities between January and February 2020. Moreover, Kraemer *et al*. (2020) show the spatial distribution of COVID-19 cases in China was strongly associated with human mobility patterns. The authors also highlight that travel restrictions in China were especially useful in the early stage of the COVID-19 outbreak. In Sao Paulo city, Candido *et al*. (2020) show that restrictions in mobility significantly decreased the R (COVID-19 reproduction number), although contamination increased through time, when population mobility became stronger. These studies suggest that more intense preventive measures should be considered in the centralities more intensely related to potential centers of COVID-19 dissemination.

Compliance with social distancing in large cities matters, affecting not only the local population but also virus dissemination to medium-sized and small cities within connected states, provinces and countries. Moreover, COVID-19 outbreaks generally increase with city size within urban networks (RIBEIRO *et al*., 2020; STIER *et al*., 2020). Examining the Brazilian cities, Ribeiro *et al*. (2020) show that small towns seem more vulnerable to COVID-19 dissemination in the initial spread of the disease when considering the infection proportionally. However, the authors show that the incidence of cases and deaths in large urban centers is higher in the long-term. Further research might investigate with some detail the effect of large centers on virus dissemination within urban networks worldwide. In addition, the timing of adoption of social distancing measures in large cities might affect the onset and spreading strength of the virus within states, provinces and regions. In Minas Gerais state, Brazil, the region of influence of Belo Horizonte presented a lower COVID-19 contamination speed when compared to the regional urban network led by the city of Sao Paulo. Social distancing measures started on March 20 in Belo Horizonte, just four days

after the record of the first COVID-19 case in the city (MINAS GERAIS, 2020). In contrast, the city of Sao Paulo recorded 396 cases up to this same date, when local authorities took restrictive measures too (MINAS GERAIS, 2020; SAO PAULO, 2020b).

In the early stages of the COVID-19 pandemic, worldwide media noticed an immediate population dispersing effect from large cities towards the interior associated with the most restrictive measures of social distancing or lockdown. As an example, India exhibited an unprecedented exodus from large cities, such as Mumbai, to smaller cities and rural areas after authorities announced the imminent lockdown period (BISWAS, 2020). The concentration of services in large cities, such as educational services, and the sudden closure of these activities, probably affected regional mobility. In this sense, early restrictive measures adopted in the capital of Minas Gerais, Belo Horizonte, probably prevented the intensification of COVID-19 dissemination in connected middle-sized and small cities at the beginning of the pandemic. There are still no scientific studies investigating this dispersing effect on COVID-19 dissemination within urban networks by using social and epidemiologic data.

In an ideal world, where COVID-19 can be efficiently tracked, restrictive measures in cities could be in line with the spread of the virus within urban networks. However, most cities and regions presented poor data and information about the virus dissemination at the beginning of the pandemic. Therefore, widespread restrictive measures were especially important for governments working to strengthen and optimize health system capacities in the first weeks of the pandemic. If urban networks are relevant in the dissemination of the virus, structuring the supply of health services according to the logic of the networks is also essential for a better response to pandemic events at the regional level.

Regions presenting balanced urban networks, without urban macrocephaly, would probably be more adapted to pandemic events when adopting restriction measures. The relatively low levels of COVID-19 dissemination in Germany (738,094 cases and 11,994 deaths until November 12, according to the Federal Ministry of Health of Germany) might be associated not only with restriction measures, but also with regional distribution of population and functionalities in the territory. Germany presents a balanced urban network system, deconcentrating people and services across the territory. Further research might investigate whether or not this association exists in other affected areas. In contrast, the interdependence of urban centralities in a balanced and highly dynamic network could lead to the rapid spread of the virus if restriction measures are not considered. However, states and regions presenting urban macrocephaly, where one city concentrates most of the population, may be even more vulnerable to covid-19. For example, the state of Amazonas (3.87 million people) in Brazil, which concentrated 46.25% of its population in the city of Manaus (1.79 million people) in 2010 (IBGE, 2010), presented a challenging epidemiological dynamic given the rapid dissemination of COVID-19 (BUSS *et al*., 2021; FARIA *et al*., 2021; MAAS *et al*., 2019). The explosion of cases in Manaus and the absence of health centers close to human settlements in most of the state territory (1.571 million km²)

posed immense challenges for authorities working in a concentrated and dysfunctional urban network. Further studies might investigate with some detail the effect of distinct urban networks on regions' level of vulnerability to respiratory pandemics.

COVID-19 and urban socio-spatial segregation in perspective

Distinct levels of poverty, inequality and social exclusion provide different conditions and capacities for people and communities to face the COVID-19 pandemic. Understanding poverty as a multidimensional phenomenon in cities seems to be even more relevant in times of pandemic, given the diversity of aspects associating poverty with vulnerability to COVID-19 in cities worldwide, as we highlight in this regard. Here, we also address how inequality and social injustice in urban centers have important spatial repercussions for combating COVID-19 in large cities.

In a recent literature review, Sathler and Leiva (2021) identified many factors associating poverty and social vulnerability to pandemics within cities, metropolitan areas and regions. Poverty is usually related to overcrowded homes and occupations that do not allow home-office activities, which reduce social distancing levels within urban areas (PATEL *et al*., 2020). Previous studies have demonstrated that poverty is also associated with the following aspects: low levels of personal knowledge about pandemics, vulnerable employment, high incidence of comorbidities (such as obesity, diabetes and hypertension), limited savings and high dependence of public services (MENDENHALL *et al*., 2017; TIMMERMANN, 2020). Additionally, economic stagnation associated with policies restricting services and industrial activities within cities can increase poverty and food insecurity, especially in developing countries (SUMNER *et al*., 2020; MARTIN *et al*., 2020).

We have recently learned that cities presenting high levels of inequality are more vulnerable to the COVID-19 pandemic (ALI *et al*., 2020). Unequal cities require multiple public policies addressing distinct social groups, once people and communities present different demands during pandemics, which may change according to place of residence, family structure, available urban services and equipment, mobility, as well as the ability to understand the risks. COVID-19 had a devastating effect on cities and regions with high inequality, given the higher lethality of the disease among black and poor people (ALI *et al*., 2020), and the greater impact of treatment costs on the budget of less privileged families, especially in countries lacking universal public health services. In the capitalist city, social groups usually have different access to health facilities. The level of access to health services is generally associated with the place of residence within the city and region. Therefore, according to Patel *et al*. (2020), the repeated phrase "COVID-19 does not discriminate" is a dangerous myth.

In the city, high levels of inequality and social injustice are associated with high levels of social tension (PITOMBEIRA; DE OLIVEIRA, 2020), which affects the resilience and organizational capacity of urban communities during health crisis. Urban theorists

understand the city as a meeting space, in which social relations can create a fertile ground for mobilization (CASTELLS, 1983; HARVEY, 1991). The organization of social groups in the urban space is vital for the strengthening of democratic practices and for the achievement of the right to the city (LEFEBVRE, 1968). During the pandemic, temporary social distancing measures imposed new strategies for social organization, most often in virtual environments. However, some sectors of society or social movements are not always willing to respect the social distancing restrictions imposed by local authorities.

Several studies demonstrated that poverty, social conditions and structural racism might be associated with higher rates of COVID-19 infection and deaths, especially in countries presenting high levels of inequality, such as the United States and Brazil. In the United States, Finch and Hernández Finch (2020) reveal that the number of deaths have been higher among urban communities presenting a larger percentage of people living in poverty and deep poverty in the ten first weeks of the outbreak. In addition, Henry (2020) finds that U.S. counties where the population was mostly non-white presented a COVID-19 rate nine times higher than counties with the same median income that are substantially white. In Brazil, there is a positive correlation between COVID-19 incidence and the percentage of people living in poor households and spending more than one hour to reach the workplace (OECD, 2020). In Sao Paulo city, Li *et al*., (2021) demonstrate that people with low-socioeconomic-status and/or black and *pardo* people (presenting mixed ethnic ancestries) presented lower levels of social distancing during the COVID-19 pandemic, facing higher risks of contamination and death.

Socio-spatial segregation materialized in urban forms and expressed in social relations between individuals in the territory affect the performance and design of policies combating the spread of COVID-19 in large cities, especially in developing countries. Sprawling urban forms that have large poor and monofunctional peripheries create immense challenges for implementing a sustainable urban routine during the COVID-19 pandemic, especially when associated with inadequate conditions of urban infrastructure and insufficient supply of public services in the city. In the developing world, inequality among municipalities can hinder integrated actions addressing COVID-19 dissemination developed by local autonomy administrations within urban metropolitan areas. For example, Sao Paulo city presents significantly more human and material resources to deal with this pandemic than other municipalities within the metropolitan area, such as Caieiras, Francisco Morato and Franco da Rocha. We believe that economic and political mediations provided by the state authorities are vital for the development of integrated policies seeking to reduce the COVID-19 dissemination within metropolitan areas.

The urban expansion of developing countries created several segregated and informal territories. Low-income population was displaced from the central areas due to the increase in land prices towards less privileged areas of urban expansion (peripheries) or less structured residual areas of formal urbanization (VILLAÇA, 2011). These territories were generally neglected during the planning process, especially in large cities, such as Sao

Paulo and Mumbai. Urbanization in these cities has materialized large territories of socio-spatial exclusion, given the concentration of investments in infrastructure and services in the most valued central areas.

Urban mobility between center-periphery typically presents serious problems in large cities and metropolitan areas in developing countries, such as the high average travel time, limited route availability and poor vehicle quality. In the periphery, the great distance from urban centers and employment centers reduces the economic viability of transport services, requiring financing mechanisms often unavailable. In this configuration, vehicles must travel long distances to serve a population dispersed in the territory, which reduces the number of payers per kilometer. In Sao Paulo, bus transport performing long routes and crossing high-density areas within the main centers is the only option for most vulnerable people living in poor suburbs. The average travel time among public transport users in Sao Paulo exceeds one hour (ODSP, 2017), which enhances exposure to the risk of COVID-19 contamination during the trips. Local news demonstrated that budget restrictions and the lower demand in Sao Paulo between 2020 and 2021 contributed to decreasing the transport availability during this pandemic, which forced essential service workers to use crowded buses (CAPARICA, 2021; PADIN, 2021).

In developing countries, the age structure and household composition in the poor peripheries is clearly distinct from the wealthier areas. The demographic transition process advances in a notoriously unequal way in these societies, causing a more pronounced fall in fertility and in the size of the families of upper and middle classes compared to the poor population (WIETZKE, 2020). Thus, the population age structure in poor neighborhoods is significantly younger. In Brazil, 26% of the population living in the slums is under 14 years old, while only 8% is over 60 years old, which is lower than the national average in 2010 (13%). Therefore, it seems that the suburbanization and population sprawl within developing countries could be important allies in tackling the COVID-19 pandemic given the low percentage of elderly people in the population.

Fewer elderly people would mean less lethality by COVID-19 among poor people living in slums. However, despite this low percentage, the elderly population living in slums is numerous (984,000 people in 2010) (IBGE, 2010). As highlighted by Hilton and Keeling (200), the most deprived suburbs within cities from developing countries present a higher average of residents per household (HILTON; KEELING, 2020). This demographic aspect challenges social distancing policies and makes social distancing complex for the elderly population. In Sao Paulo, the 598,324 households located in the slums are home to an average of 3.63 residents in 2010, which is higher than the average for the metropolitan region (3.17) (IBGE, 2010). In addition, other risk factors associated with poverty already explained in this section significantly increase the risks of this elderly population.

Household composition affects social distancing levels in central and peripheral areas. In Sao Paulo, only 9.8% of people were living alone in 2010 (1.1 million people) (IBGE, 2010). The serological survey conducted between August 25 and 27 in Sao Paulo

indicates that 19.8% of people over 18 years of age living in households with more than five residents have antibodies to the disease, a percentage higher than the city average (13.9%) (SÃO PAULO, 2020). In Manhattan, 50.3% of residents lived alone in 2008, which is higher than the figures presented by other New York boroughs (27.5%) and Los Angeles (30.2%) (U.S. CENSUS BUREAU, 2008). In fact, different types of households present distinct vulnerabilities, with one-person households less likely to contribute to COVID-19 dissemination in the neighborhood (MIKOLAI *et al*., 2020).

Furthermore, urban form might catalyze virus dissemination in the biggest slums. The predominance of narrow alleys, the lack of retreat between homes, the small size of households and the high average of residents per household reduce the daily physical and social distancing in these areas. The low coverage of basic sanitation in the poorest suburbs of the city demonstrated by Andersson *et al*. (2016) also raises great challenges for the control of the pandemic.

Cities with immense poor peripheries are more vulnerable to social distancing measures, such as closing schools and economic activities. According to Lancker e Parolin (2020), school closures can exacerbate food insecurity, since poor students generally depend on school meals to obtain a rich and balanced diet. In addition, all over the world, low-paid workers from the most affected sectors (such as restaurants, culture, leisure) presented the highest reduction in income during the most critical moments of city closings. Therefore, social distancing measures must be accompanied by policies to alleviate their economic and social effects.

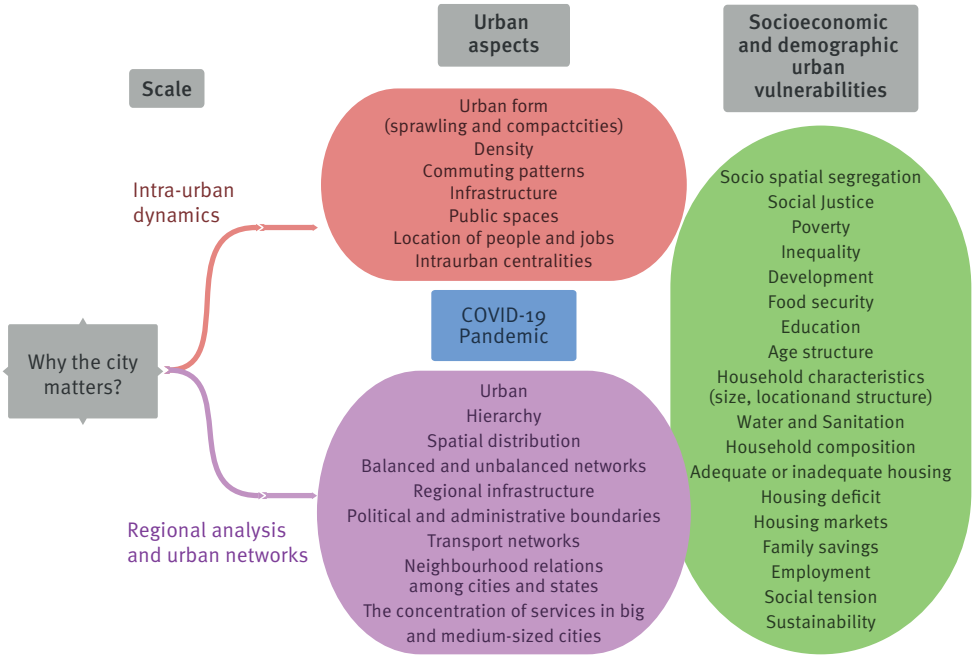
In history, employment and division of labor have been strongly associated with socio-spatial changes within cities (from the Greek City-states to the postindustrial metropolis) (MUMFORD, 1961; SOJA, 2000). In the urban society, contemporary cities concentrate jobs, especially in the industrial and service sectors. In 2020, COVID-19 severely affected labor markets in urban areas, penalizing occupations that do not allow home-office activities. Considering the number of employed people in New York/Newark/Jersey, Los Angeles/Long Beach/Anaheim and Sao Paulo metropolitan region in November (9,49 million, 6,2 million and 6,3 million, respectively), the COVID-19 pandemic hit New York and Los Angeles harder than Sao Paulo in terms of employment levels and pace of recovery (BRAZIL, 2020; U.S. CENSUS BUREAU, 2020). These differences are closely related to legislation specificities between United States and Brazil (L&E GLOBAL; TOZZINI FREIRE, 2020), not necessarily reflecting different levels of COVID-19 dissemination.

Policymakers must develop a more comprehensive understanding of the idea of a risk group within cities, incorporating not only individuals who have multiple comorbidities, but also people and communities with high vulnerability associated with social, economic and spatial factors. The manifestations of poverty, unemployment and social inequality in space pose immense challenges for local authorities, increasing the complexity of implementing policies to mitigate and adapt cities to this new epidemiological reality. Specificities of the poorest peripheries, such as the high average number of residents per household,

long distance from service centers and high percentage of the population dependent on precarious public services, must be addressed in times of pandemic, seeking not only to solve problems in the short term, but also to build a long-term legacy for cities.

Our analysis suggests that cities and regions present multiple urban aspects and socioeconomic characteristics that must be considered when investigating the COVID-19 dissemination and designing combat strategies against pandemics. A single variable, such as density, will not, by itself, explain differences in contamination patterns among large centers. However, density, as well as other variables such as urban form, population stock, poverty and inequality, can be relevant in approaches exploring COVID-19 dissemination as a multidimensional phenomenon within cities and regions. Finally, we present a diagram summarizing the main elements explored in this paper during our search – in the context of COVID-19 – for an answer to the following question: "why does the city matter?" Figure 4 suggests that we have multiple interdependent variables within cities and regions that must be taken into account when studying COVID-19 dissemination.

FIGURE 4
Diagram summarizing the main elements associating multiscale urban aspects and with COVID-19 dissemination



Source: Elaboration of the authors.

Conclusion

In this study, our literature review shows that "the city" must be at the center of the debate when investigating COVID-19 dissemination in territory. Based on the literature revision, this study shows that the associations between COVID-19 dissemination and urban aspects are better addressed when considering multidimensional perspectives. Intra-urban dynamics, such as urban form, density, infrastructure and commuting patterns, as well as characteristics presented by urban networks can affect COVID-19 dissemination within cities, metropolitan areas and regions. In addition, socioeconomic and demographic urban aspects, such as poverty, inequality, social justice, age structure and sociospatial segregation can increase the vulnerability of cities and regions to pandemics, especially within developing and undeveloped countries.

Here, we conclude that compact cities, such as New York, are more vulnerable to pandemics in the early stages, when social distancing measures are not adopted by authorities and scientists have a poor understanding of the disease. In sprawling urban settlements dominated by cars and buses crossing low-density areas, such as Los Angeles metropolitan area, urban form and structure can contribute to curbing the COVID-19 dissemination in this pandemic stage. In fact, Los Angeles recorded lower infection and mortality rates in the first months of the pandemic in spite of presenting less mobility restrictions than New York. However, epidemiologic data suggest that local public policies, such as social distancing initiatives, use of masks and economy lockdown, were decisive in the control of COVID-19, since Los Angeles presented worse epidemiologic outcomes than New York in the medium term. As humans can learn how to manage pandemics better within cities and regions, dissolving democratic urban projects based in compactness does not seem reasonable and will not produce appropriate long-term outcomes.

Our literature review shows regional thinking also matters when investigating the spatial patterns exhibited by COVID-19 dissemination in the territory. COVID-19 dissemination will not respect administrative boundaries if urban networks do not follow political rules. Regional organization, urban hierarchy and urban networks can play a relevant role in defining places and routes where COVID-19 are more likely to spread. Therefore, actions seeking to curb the COVID-19 dissemination must consider the regional scale within territories.

Additionally, unequal cities exhibiting extensive poor peripheries face great challenges in combating COVID-19 dissemination. In Sao Paulo, the larger population stock, the higher diversity of urban forms and household composition in the suburbs challenge authorities seeking to manage COVID-19. In the large suburbs of Sao Paulo, the majority of the population has no access to cars and faces higher risks of exposure to the virus in public transport, which make the implementation of a sustainable reopen during this pandemic difficult.

Finally, this paper provides relevant pathways for future researches exploring in some detail the urban dimensions of the COVID-19 pandemic. Knowledge of the epidemiological dynamics within cities, metropolitan areas and regions from the perspective of urbanists and urban geographers allows for the design of better strategies to contain contamination in the epicenters of the disease, preventing them from spreading in the territory. Improving our knowledge on this topic can help authorities and scientists reduce the vulnerability of cities and regions worldwide to pandemics, building sustainable spaces that concentrate ideas, resources and solutions.

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Resumo

A cidade importa: urbanização, análise regional e segregação urbana em tempos de pandemia de Covid-19

No início de 2020, assentamentos urbanos em todo o mundo experimentaram a rápida expansão da síndrome respiratória aguda grave (SARS-CoV-2). As cidades foram os focos de contaminação nos países que apresentaram notificações significativas de Covid-19. Neste estudo, investigamos primeiramente a disseminação da Covid-19 entre cidades espraiadas e compactas, examinando aspectos como densidade urbana, localização de pessoas e empregos e padrões de deslocamento. Nessa análise, a literatura anterior e os dados recentes de três grandes cidades distintas (Nova York, Los Angeles e São Paulo) apoiam a discussão. Com base na revisão da literatura, demonstra-se que a morfologia urbana, a infraestrutura e os projetos de mobilidade e atividades econômicas são aspectos relevantes do desenvolvimento urbano que podem afetar as interações entre os cidadãos e a disseminação da Covid-19. Além disso, observa-se que a escala regional e a análise da rede urbana também são importantes nos estudos que investigam o crescimento da Covid-19. Por fim, a a revisão da literatura mostra que a vulnerabilidade socioespacial urbana é relevante em tempos de pandemia, diante das associações entre a disseminação da Covid-19 e aspectos socioespaciais nas cidades, como pobreza e desigualdade.

Palavras-chave: Urbanização. Análise regional. Segregação urbana. Covid-19. Pandemia.

Resumen

La ciudad importa: urbanización, análisis regional y segregación urbana en tiempos de pandemia de COVID-19

A principios de 2020, los asentamientos urbanos de todo el mundo experimentaron la rápida expansión del síndrome respiratorio agudo severo (SARS-CoV-2). Las ciudades fueron los puntos críticos de contaminación por el virus dentro de los países que presentaron notificaciones significativas de COVID-19. En este estudio, primero investigamos la diseminación de COVID-19 en grandes ciudades compactas y extensas, y examinamos aspectos como la densidad urbana, la ubicación de personas y trabajos, y los patrones de desplazamiento. En este análisis, la literatura previa y los datos recientes de tres distintas grandes ciudades (Nueva York, Los Ángeles y San Pablo) apoyan nuestra discusión. Aquí, confirmamos que la morfología urbana, la infraestructura, los proyectos de movilidad y las actividades económicas son aspectos relevantes del desarrollo urbano que pueden afectar las interacciones entre los ciudadanos y la difusión de la COVID-19. Además, demostramos que la escala regional y el análisis de redes urbanas también son importantes en los estudios que investigan el crecimiento de COVID-19. Finalmente, investigamos la vulnerabilidad socioespacial urbana en tiempos de pandemia, destacando las asociaciones entre la diseminación de la COVID-19 y aspectos socio-dentro de las ciudades, como la pobreza y la desigualdad.

Palabras clave: Urbanización. Análisis regional. Segregación urbana. COVID-19. Pandemia.

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