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Cities and Public Health in Latin America

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Abstract*

This paper presents an overview of how health outcomes vary across cities in Latin America and discusses some of the known drivers of this variation. There are large disparities in outcomes across cities and across neighborhoods of the same city. Because health is closely related to the socioeconomic conditions of individuals, part of the spatial variation reflects residential segregation by income. Local characteristics also have a direct effect on health outcomes, shaping individuals' access to health services and the prevalence of unhealthy lifestyles. In addition, urban environments affect health through natural atmospheric conditions, through local infrastructure – in particular water, sanitation, and urban transit – and through the presence of urban externalities such as traffic congestion, pollution, crime, and the spread of transmissible diseases. The COVID-19 pandemic illustrates many of these patterns, since the impact of the disease has differed sharply across cities, and much of this variation can be explained by observable local characteristics – particularly population, connectivity with other cities and countries, income levels, and residential overcrowding.

JEL classifications: I18, R10, O18

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1 Introduction

In highly urbanized countries, like most of those in Latin America and the Caribbean, public health issues are largely urban issues. Most preventive and curative healthcare occurs in cities, individuals' health-related lifestyle decisions take place in – and are constrained by – urban environments, and urban dwellers are exposed to externalities[1] that rarely exist in rural areas, and that can have large impacts on health outcomes.

Two defining characteristics of cities are population density and the geographic agglomeration of economic activity. While researchers have emphasized the productivity effects of agglomeration, there is also a strong connection between agglomeration and health outcomes (Ahlfeldt and Pietrostefani, 2019). On the one hand, cities create conditions that hurt public health. Contagious diseases tend to spread faster in denser localities, and their populations tend to be more exposed to traffic congestion and polluting emission (Bryan et al., 2020). On the other hand, density creates opportunities for economies of scale in the production and provision of public goods and services, including healthcare. Studies have shown, for example, that the response time in emergency medical services is smaller in more densely populated locations (David and Harrington, 2010), and that costs of producing laboratory tests is lower in places with higher agglomeration of hospitals (Friedson and Li, 2015). Whether the positive effects of density dominate the negative effects is an open question, and the answer is likely to vary depending on the context.[2]

Health disparities are typically present not only across cities of different characteristics, but also across neighborhoods within the same city. People with more limited access to health services due to their socioeconomic conditions also tend to live in neighborhoods that are more exposed to urban externalities, including traffic congestion, pollution, and crime. Already-vulnerable populations are disproportionately affected by the downsides of urban density and have less access to its positive effects. This implies that policies seeking to reduce health disparities in Latin American cities need not only come from national governments. Local governments can also play a decisive role as policymakers in this context.

This paper presents an overview of the connection between the urban environment and public health in Latin America, exploring spatial differences at various geographic levels. Section 2 describes how health outcomes vary across and within cities in the region.

[1]In Economics, an externality refers to a cost of a benefit inflicted on third parties as a byproduct of self-interested behavior.

[2]For example, Ahlfeldt and Pietrostefani (2019) find that population density is positively associated with life expectancy at birth across OECD subnational regions, while Reijneveld et al. (1999) finds it is positively associated with mortality risk across postcodes in the Netherlands.

Section 3 discusses the correlates of these spatial disparities, and the policies that local and national governments have deployed in response. Section 4 turns to the local impact of the COVID-19 pandemic in Latin American cities. Section 5 offers concluding remarks.

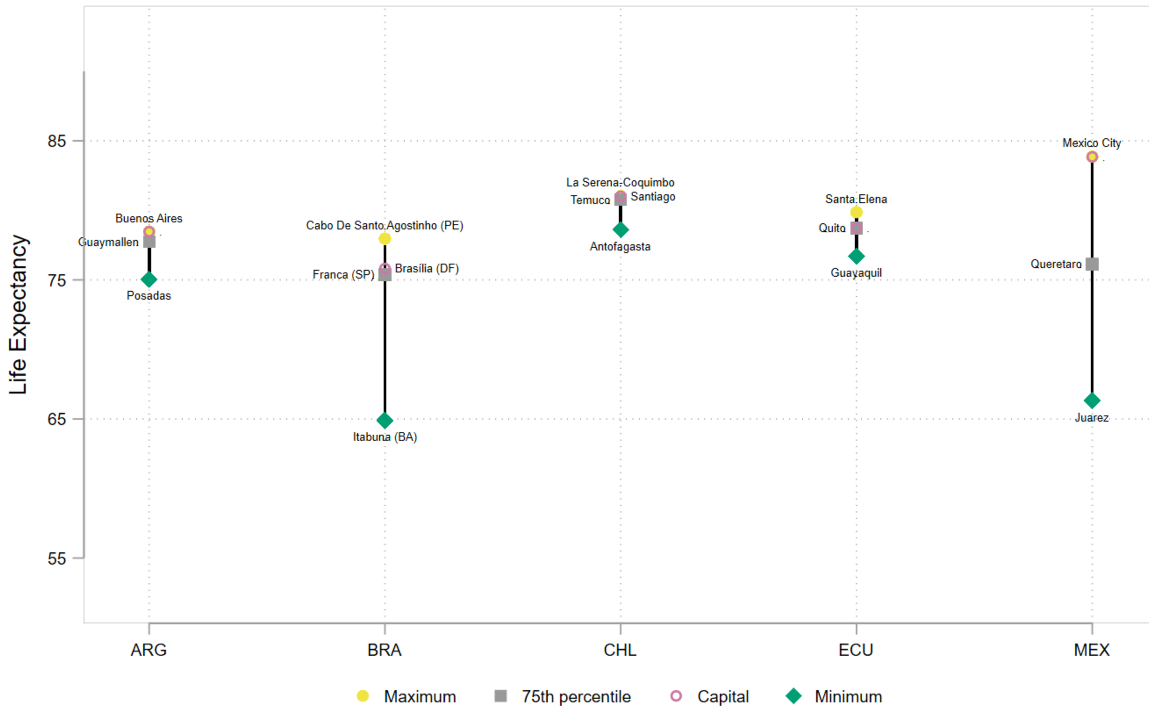
2 Spatial Disparities in Health Outcomes

2.1 Differences in Health Outcomes across and within Cities

Health outcomes, including under-5 mortality, median life expectancy at birth, and the incidence of various infectious diseases have been improving in the region over the last few decades, although they still lag relative to those in the OECD countries (Berlinski et al., 2020). Even so, meaningful disparities remain across cities in the region. Males have a 6-year lower life expectancy in Mexico City than in Santiago, Chile, and the gap is almost 8 years for females (Bilal et al., 2019). To take another example, the prevalence of overweight in the population aged 0-19 – as defined by the International Obesity Task Force (IOTF) - is about 3.5 times higher in Tijuana, Mexico than in Ouro Preto, Brazil (Rivera et al., 2014). Moreover, even though the gaps across cities of different countries are large, Ortigoza et al. (2020) find that, across 286 Latin American cities, most of the variation in infant mortality rates (57%) takes place across cities within the same country.

Figure 1 illustrates this phenomenon using life expectancy estimates calculated for 188 cities of population 200,000 or higher in five countries of Latin America. Even in countries with a more homogeneous geographic distribution – like Argentina, Chile and Ecuador – the difference between the top and bottom cities in this category can be on the order of two to three years – almost the same as the country-level gap between the United States and Brazil in 2015. In Brazil, that difference is 13 years, and in Mexico 17 years, which is similar to the gap between the United States and Haiti, the poorest country in the Western Hemisphere, also in 2015 (United Nations and Affairs, 2019). There are also large differences across cities in the region in the conditions most associated with mortality. Bilal et al. (2021) show, in a sample of 363 cities in Latin America, that the proportion of deaths attributable to communicable, maternal, neonatal and nutritional (CMNN) conditions can range from 6% to 55%, and the proportion attributable to cardiovascular diseases (CVDs) and other noncommunicable diseases (NCDs) can go from 28% to 71%.

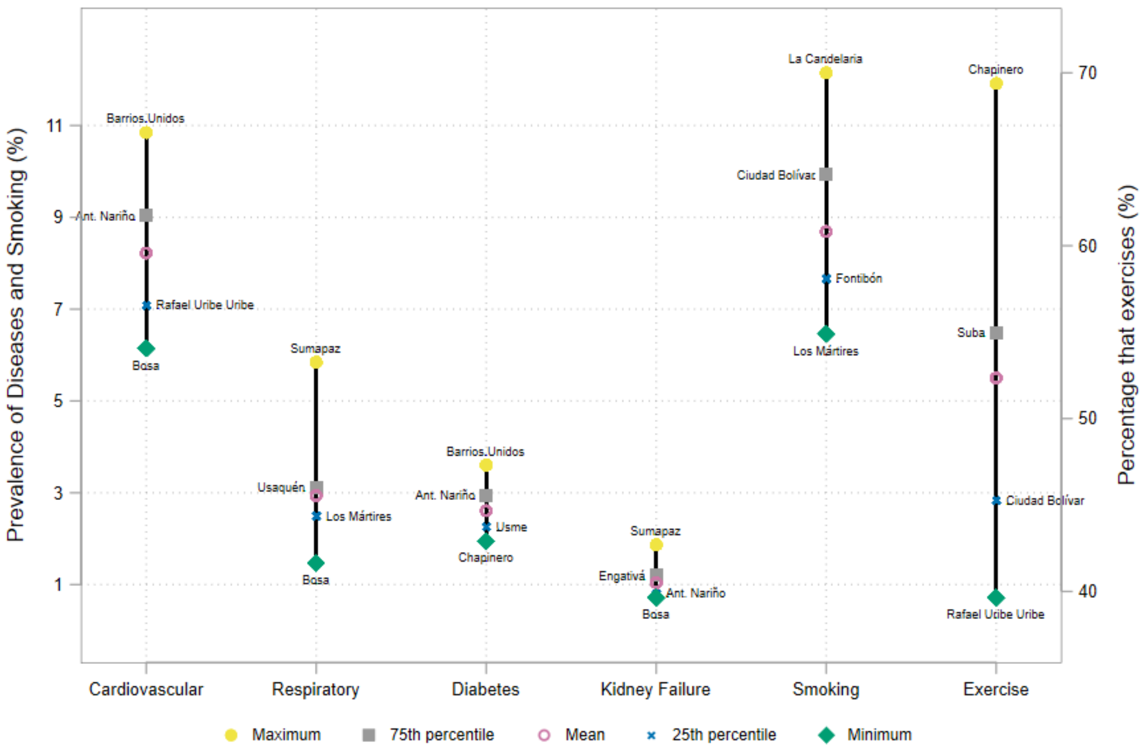
Figure 1: Differences in Life Expectancy across Cities in Five Latin American Countries



Note: Author's calculations using data from 188 Latin American cities with population of at least 200 thousand (22 from Argentina, 81 from Brazil, 11 from Chile and Ecuador, and, 63 from Mexico). City definitions are adjusted to make them comparable across countries. Life expectancy is computed using standard life tables as defined by WHO (2014). Notice that age-specific mortality rates are not adjusted by mortality patterns or uncertainty from under-registration as in Bilal et al. (2021). Population and mortality data are taken from the National Institute of Statistics or the Ministries of Health. Data come from INDEC and MSAL(Argentina); IBGE (Brazil); INE (Chile); INEC (Ecuador) and INEGI (Mexico).

In addition to large differences in health outcomes across cities, health disparities across neighborhoods within the same city can also be substantive. Figure 2 illustrates this with data from 20 sub-city localities from Bogotá, Colombia. While the prevalence of some non-transmittable diseases – such as diabetes and kidney failure – is relatively homogeneous across localities, in others there are large within-city differences. For instance, the prevalence of cardiovascular disease in the most affected locality, Barrios Unidos, is almost twice as large as in the least affected, Bosa. In the case of respiratory diseases, the gap between the highest and the lowest-incidence localities is almost sixfold. These within-city disparities are not only observed in health outcomes, but also in health-related behaviors. The incidence of smoking in La Candelaria locality is about twice as high as in Los Mártires locality, and the share of the population that regularly exercises in Chapinero locality is strikingly around 1.75 times higher than in Rafael Uribe Uribe.

Figure 2: Differences in Health Outcomes across Bogotá's Localities

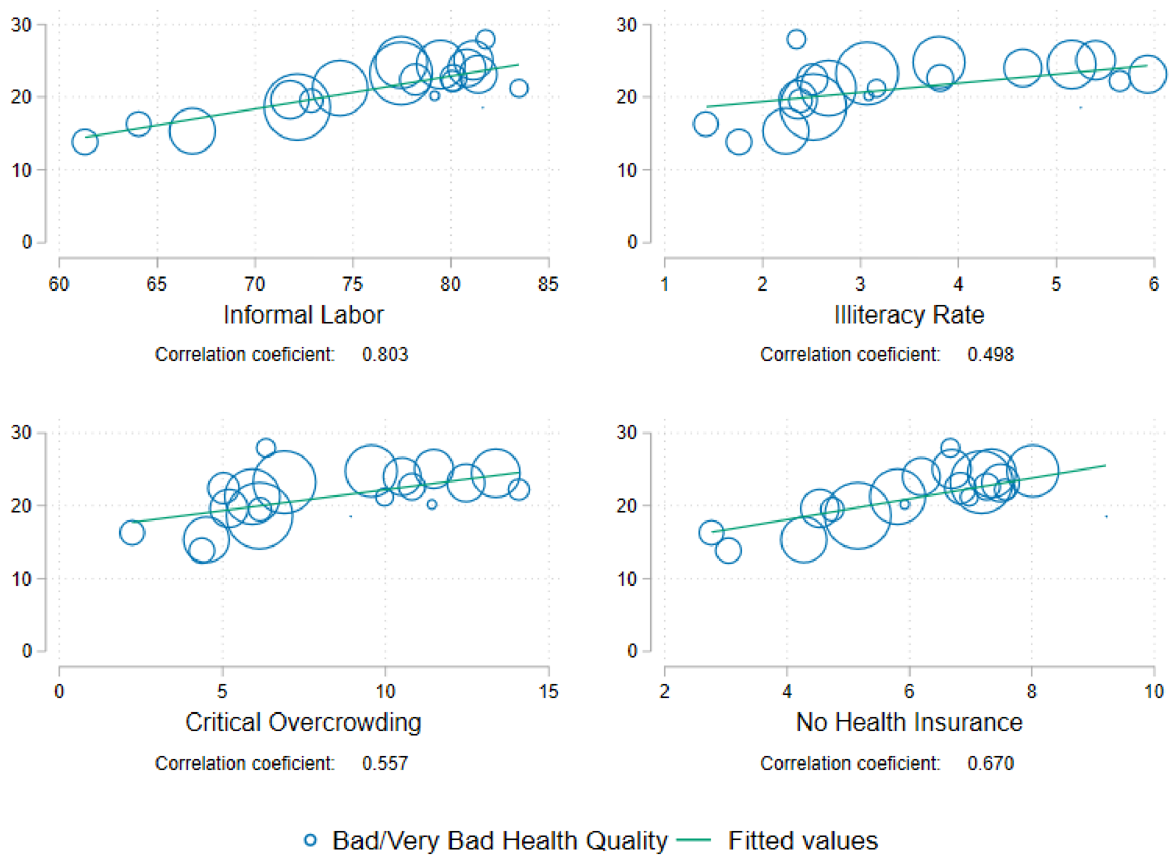


Note: Author's calculations with data from the 20 Localities of Bogotá. Localities include all neighborhoods (N=1,922). Data are taken from the Multipropósito Survey (SDP, DANE and Gobernación de Cundinamarca, 2017).

2.2 Health Outcomes and Socioeconomic Conditions

Spatial differences in health outcomes are frequently connected with spatial differences in income and other socioeconomic indicators. Figure 3 illustrates this with a set of scatter plots that show how different variables correlate with the prevalence of individuals with "bad" or "very bad" health quality across sub-city localities in Bogotá, according to data provided by the city's 2017 Multi-Purpose Survey. Here, each marker represents a locality in Bogotá, and the markers' sizes are proportional to the total population of each locality. Along different socioeconomic indicators, localities that are disadvantaged also tend to have a higher incidence of poor health. Individuals with bad or very bad health tend to reside in areas with a larger share of the population working in the informal sector, where wages are lower, and with a higher incidence of illiteracy, which limits their ability to compete in a workplace where demand for skills is permanently increasing. They also tend to live in smaller dwellings, making critical residential overcrowding more prevalent. Furthermore, they are less likely to have health insurance, limiting their access to health providers (public or private) and thus exposing them to greater risk of health complications.

Figure 3: Correlates of Bad Health Indicators in Bogotá



Note: Localities (N=20) are weighted by their population. Localities include all neighborhoods (N=1,922). Bad health is measured as the proportion of respondents that described their health insurance service as “bad" or “very bad". DANE defines critical overcrowding as those households with more than three people per room. Informal workers are those individuals working in enterprises with up to five workers. For further details see DANE (2009,1). No health insurance is measured as the percentage of individuals that report not being affiliated with any social security entity, either from the private sector (*contributivo*) or from the public regime (*subsidiado*). Informal labor, illiteracy rate and critical overcrowding are taken from the 2018 National Census (DANE, 2018). No health insurance comes from the *Encuesta Multipropósito* (SDP, DANE and Gobernación de Cundinamarca, 2017).

These geographic patterns partly reflect differences in the demographic composition of neighborhoods, as health outcomes are closely correlated with individuals'socioeconomic conditions. People with lower education levels – a variable associated with lower income – are more likely to suffer from two or more health risk factors, such as hypertension or high cholesterol, relative to people with secondary schooling or higher education (Berlinski et al., 2020). At the same time, people with similar socioeconomic characteristics tend to cluster together and away from other socioeconomic groups within urban areas. With a few notable exceptions, lower-income families in Latin America tend to locate further away from the economic centers of cities, in neighborhoods where housing is more affordable (Chauvin and Messina, 2020).

However, spatial health inequalities are not fully explained by such composition effects. The environment in which a person lives and works can also directly affect health. Even after controlling for personal characteristics and how they affect the sorting of people into neighborhoods, place-level characteristics continue to be associated with health outcomes. In Italy, Bilger and Carrieri (2013) document that living in a bad vs. good quality neighborhood – in terms of pollution, noise and crime – is associated with a nearly 6% higher likelihood of suffering from chronic disease. In the United States, beneficiaries of a housing vouchers lottery who were able to move to lower-poverty and safer neighborhoods experienced significantly better mental health outcomes relative to eligible individuals who were not favored in the lottery (Kling et al., 2007). We turn next to discussing three possible ways in which place-level characteristics can affect individual health: differences in access to health services, in health-related behavior, and in features of the urban environment that lead to differences in health outcomes.

3 Correlates of Spatial Health Disparities

This section explores local characteristics that correlate with the spatial variation in health outcomes discussed above, as well as related recent academic research. Some of these – like access to urban transit – are specific to cities. Others – such as unhealthy natural conditions or access to water and sanitation – are relevant in both urban and rural areas, but given the high urbanization levels of Latin America and the Caribbean, most of the population of the region experiences them in cities.

3.1 Health and Urban Environments

3.1.1 The Natural Environment of Cities

Perhaps the most conspicuous way in which the place where people live affects their health is through weather and other atmospheric conditions. The location of cities determines their exposure to different temperatures, precipitation levels, and altitudes. These conditions in turn determine the exposure of cities' populations to a variety of health risks. These risks are likely to worsen over time, as climate change brings about more frequent episodes of extreme weather (Harlan and Ruddell, 2011; McMichael and Lindgren, 2011).

Areas with tropical weather conditions are more exposed to mosquito-transmitted diseases, such as malaria, dengue and zika, and cities frequently have conditions that are more favorable for the proliferation of such diseases than do rural areas, including construction sites and the presence of a variety of household objects that create pockets of standing water (e.g., tires, buckets, open trash receptacles, etc.). In localities with higher average exposure, the incidence of these diseases can vary significantly from year to year due to weather conditions. De la Mata and Valencia-Amaya (2014) show that, in Colombia, municipalities that experienced higher rainfall variability within a year reported more cases of dengue. But even within urban areas exposed to very similar weather, the incidence of vector-borne infections can differ at very small geographic scales depending on the conditions under which people live (Rodriguez-Barraquer et al., 2019). Increasing evidence from Latin America and the United States shows that in utero and postnatal exposure to such diseases can have significant long-term socioeconomic e ffects. Adults who had higher exposure to malaria as children tend to have lower performance in cognitive tests (Venkataramani, 2012), lower educational attainment and literacy rates (Barreca, 2010; Carrillo, 2020; Lucas, 2010), and overall lower income (Bleakley, 2010).

Other aspects of the natural environment that can have important health implications include extreme temperatures and altitude. Romero-Lankao et al. (2013) have linked higher temperatures during cold seasons in Bogotá and Mexico City with a higher incidence of deaths from cardiovascular disease. In the United States, exposure to extreme temperatures has been linked to lower birth weight (Deschênes et al., 2009), and higher mortality rates (Barreca, 2012; Deschenes and Moretti, 2007). In the same vein, high altitudes can also be detrimental to health. In cities like Mexico City, La Paz or Quito, for instance, the particulate emissions of buses of the same technological characteristics can be as much as three times higher than at low altitudes because motors are less efficient at burning fuel at high altitudes (Giraldo and Huertas, 2019).

3.1.2 Urban Built Environments

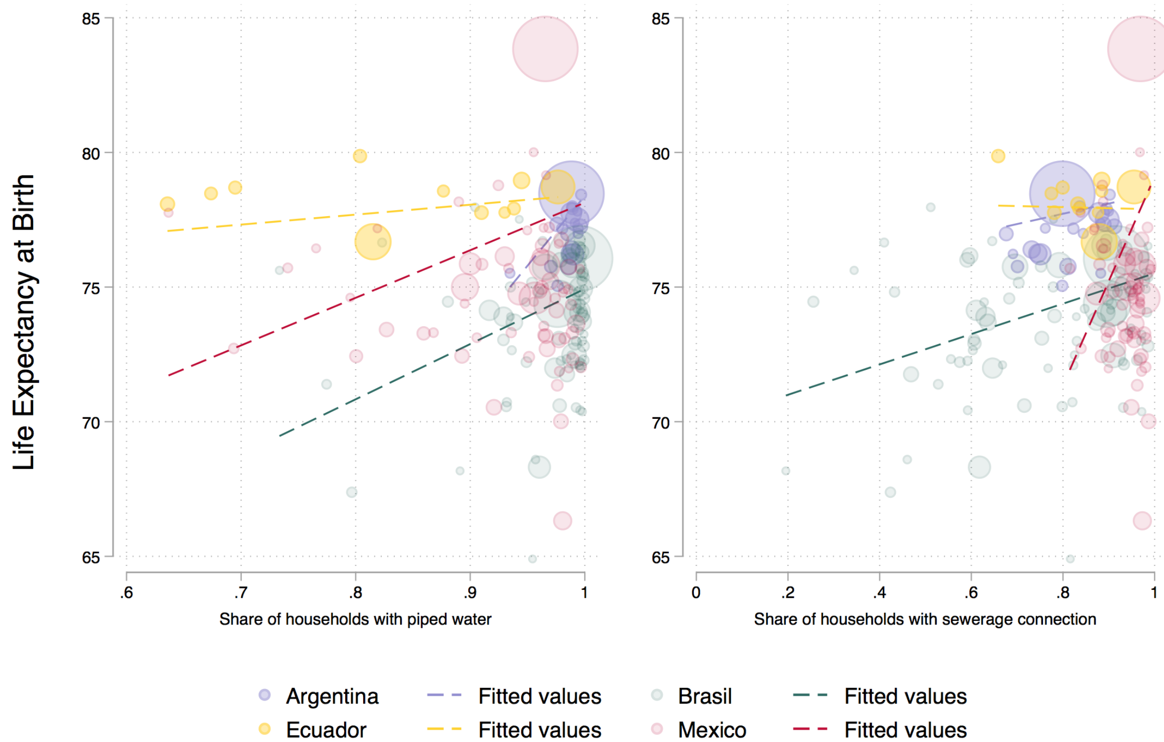
Another dimension of urban life actively shaped by policy, and which has a substantive impact on public health, is the built environment. Researchers have shown that urban infrastructures – and in particular those related to sanitation and mobility – can substantively affect individual health outcomes.

Access to safe drinking water is a first-order issue, and there is ample evidence showing a direct connection between access to water and health in Latin America. In Argentina during the 1990s, following the privatization of local water companies in close to 30% of the country's municipalities, water provision coverage expanded and quality improved in many of them. This led to an average 8% decrease in child mortality, with much stronger effects (on the order of 26%) in the poorest areas (Galiani et al., 2005). During the same period, Colombia also implemented reforms leading to greater private companies participation in the provision of local water services. In contrast with the Argentinian case, Colombian municipalities with higher private participation saw a *smaller* expansion in water coverage. However, as in Argentina, those with less water access also experienced slower improvements in child mortality (Granados and Sánchez, 2014). In Brazil, Gamper-Rabindran et al. (2010) also document that access to piped water is negatively associated with under-1 infant mortality rates, and that these effects are particularly strong in municipalities that at the baseline were at the top of the infant mortality distribution. Similar positive effects of water on health outcomes – in particular on the incidence of diarrhea and typhoid fever – has been found in multiple studies across the developing world, particularly in Africa (Ashraf et al., 2017; Kosec, 2014).

Figure 4 illustrates the connection of access to water and sanitation with life expectancy in a sample of 177 cities with a population of 200 thousand or larger in four Latin American countries. Cities in which a larger share of households have access to piped water tend to have a higher life expectancy in Argentina, Brazil, Mexico, and to a lesser extent in Ecuador. This is in line with the findings of other multi-city studies carried out in the region. In a sample of 286 Latin American cities with a population of at least 100,000, Ortigoza et al. (2020) finds that a one-standard-deviation improvement in access to piped water and sewage is associated with an 11.4% decrease in infant mortality rates. In a different sample, which includes 363 cities of the region, Bilal et al. (2021) find access to water and sanitation to be among the variables associated with higher life expectancy – along with higher education levels and lower overcrowding.

Another aspect of infrastructure closely related to health outcomes is access to waste disposal. Without an adequate system to dispose of solid and liquid waste, city-dwellers become constantly exposed to unhealthy conditions. Open defecation is associated with higher infant mortality (Geruso and Spears, 2018), and the effect is more pronounced in locations with higher population density (Hathi et al., 2017). In Latin America, people living in cities with more access to sewage tend to have a higher life expectancy (Figure 4). Furthermore, health outcomes are not only affected by the lack of working sanitation systems, but also by the side effects of delays and inefficiencies in the construction of those

Figure 4: Correlates of Mortality Rates across Cities in Four Latin American Countries



Note: Author's calculations using data from 177 Latin American cities with a population of at least 200 thousand (22 from Argentina, 81 from Brazil, 11 from Ecuador, and 63 from Mexico). Cities are weighted by their population. City definitions are adjusted to make them comparable across countries. Life expectancy is computed using standard life tables as defined by WHO (2014). Notice that age-specific mortality rates are not adjusted by mortality patterns or uncertainty from under-registration as in Bilal et al. (2021). Population and mortality data are taken from the National Institute of Statistics or the Ministries of Health. Data come from INDEC and MSAL(Argentina); IBGE (Brazil); INEC (Ecuador) and INEGI (Mexico).

infrastructures. Using data from 6,000 sewage projects implemented in Peru between 2005 and 2015, Bancalari (2020) finds that completing a project is associated with a 33% decrease in infant mortality and a 25% decrease in under-five mortality. Conversely, the presence of unfinished projects – which expose the local population to water cuts and accidents-prone excavations – were associated with a 5% *increase* in infant mortality. Galdo and Briceño (2005) also document a negative effect of the expansion of sewage coverage on child mortality in Quito.

Access to urban transit infrastructure – particularly large mass transit systems – also helps improve local health outcomes (Mackett and Thoreau, 2015). Using data from 58 subway openings in multiple countries between 2001-2016, Gendron-Carrier et al. (2021) find that, in high-pollution cities, subway openings reduce particulates by 4%, while there is a null effect in low-pollution cities. These estimates imply that, in the average city in the sample (with a population of 5.3 million and a 2% birthrate), the opening of a subway system prevents between 22 and 34 infant deaths per year. A different study focusing on large Latin American cities yields consistent results: Ortigoza et al. (2020) shows that a one-standard deviation improvement in mass transit availability is associated with a 6.6% decrease in infant mortality rates.

Other infrastructure investments that improve sanitary conditions in urban settings have also been shown to have positive effects on health outcomes. This is the case of slums upgrading programs, which deliver improvements in the housing conditions and infrastructure services in informal neighborhoods, typically inhabited by low-income families. A prominent example in Latin America is the TECHO program in Mexico and El Salvador. The intervention provided sturdy houses – either pre-fabricated or built from traditional materials – to extremely poor households living in slums. Most of the cost was covered by the participating NGO, while the families covered around 10% (approximately US$ 100). This significant improvement in housing quality resulted in a decrease of 27% in the incidence of diarrhea among children younger than 5. This effect is comparable to that of water and sewage upgrades (Galiani et al., 2017). Other examples in the region include the Favela Bairro program in Brazil, which was associated with reductions in mortality from vector-born infections and overall infant mortality; and the Piso Firme program in Mexico, which was related to reductions in children's parasitic infections, diarrhea and anemia (Corburn and Sverdlik, 2017).

3.1.3 Urban Externalities

The urban environment that people experience is not only shaped by natural conditions and built infrastructure. It is, perhaps most importantly, shaped by other people's behavior. Urban density creates the conditions for individuals to negatively impact the welfare of others in a variety of ways. Two well-known and interrelated urban externalities are traffic congestion and air pollution. After a certain number of vehicles are already circulating, the decision of each driver to get on the road slows down traffic for everyone else. All combustion vehicles generate emissions that pollute the city's air, and this is not necessarily factored into drivers' decisions of when and for how long to use their vehicles.

Urban air pollution has well-documented negative effects on health. Using a 10-year panel of 48 municipalities across Mexico City, Arceo et al. (2016) find a robust connection between air pollution and infant mortality. An increase of one microgram per cubic meter in 24-hour particulate matter (PM_{10}) increases weekly infant deaths per 100,000 by 0.23. Air pollution is also associated with higher infant mortality rates across U.S. counties (Chay and Greenstone, 2003).

As discussed above, mass transit projects appear to be an effective policy to reduce air pollution in cities. Another useful policy tool is zoning, which if adequately designed can reduce the exposure of populations to unhealthy levels of particulate matter generated by vehicles or other sources of urban air pollution such as industrial factories (Maantay, 2001; Rossen and Pollack, 2012). However, other policies that have been deployed to address this externality – in particular circulation restrictions – have a less than stellar success record in the region. For example, programs like *Hoy No Circula* in Mexico and *Pico y Placa* in Bogotá, which banned drivers from using their vehicle certain days of the week, have been associated with *increased* driving and pollution, as people who could afford it acquired additional vehicles to use during the restricted days (Bonilla, 2019; Davis, 2008). An exception is the *Pico y Placa* program in Quito, which did achieve a reduction in the concentration of carbon monoxide of 9% to 11% during peak traffic hours (Carrillo et al., 2016).

An important public health problem also related to driving externalities is road insecurity, which leads to a large number of deaths and injuries, many associated with long-term disabilities. The deaths and medical expenses linked to road transit accidents generate a great economic burden on families, particularly in low- and middle-income countries, whose economic losses related to road safety can be close to 5% of their GDP, according to some estimates (Martinez et al., 2019). National legislation, such as drinking laws (Otero and Rau, 2017) and laws regulating the use of helmets for motorcycle drivers (Blanco et al., 2018) have proved effective in reducing injuries and fatalities. While most countries in the region have enacted this kind of legislation, enforcement varies significantly across countries, and across localities of the same country (Martinez et al., 2019), and local authorities can play a pivotal role in making their cities safer for drivers and pedestrians.

Another important externality is the health risk generated by inadequately treated solid waste. Even though in Latin America and the Caribbean a high percentage of the population (close to 90%) has waste collection coverage – better than in other low and middle-income regions of the world – the predominant waste disposal method is open dumps (Hettiarachchi et al., 2018), which have been associated with various health risks such as exposure to a variety of viruses and bacteria (Cruvinel et al., 2019) or the ingestion of hazardous levels of heavy metals among children (Cittadino et al., 2020). Zoning policies can play a key role in limiting the health impact of these hazards in cities (Maantay, 2001).

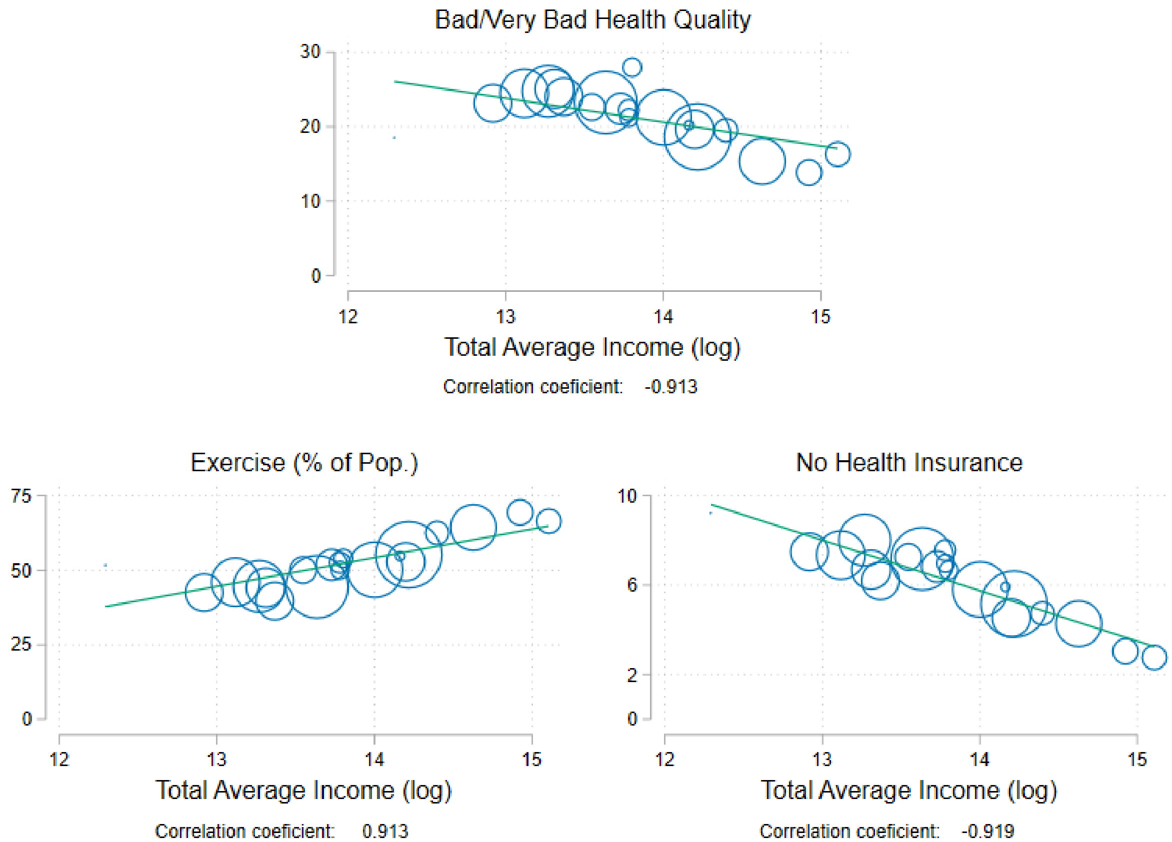
Externalities additionally play a central role in the propagation of infectious disease epidemics. The diffusion of such diseases is closely linked to the number of human interactions, which increases exponentially with the size of the urban population (Schläpfer et al., 2014). This was starkly shown during the COVID-19 pandemic, which is discussed in greater detail in Section 4.

3.2 Spatial Inequalities in Access to Health Care Insurance

Access to health care insurance can vary significantly across cities. In a health survey carried out by the Pan-American Health Organization in the early 2000s there were large differences across cities in the share of uninsured individuals, ranging from 17% in Buenos Aires, to 11% in Santiago, and to just around 2% in São Paulo and Montevideo. In a closely related finding, 80% of respondents in Montevideo reported being able to obtain an appointment within one week vs. only 59% in São Paulo (Balsa et al., 2011).

The sources of this spatial variation, in turn, are driven by a complex interaction among the regulatory system, the enforcement agencies, and the network of public and private insurers and providers. Generally speaking, socioeconomic conditions tend to be associated with health insurance coverage and health outcomes across localities. Garcia-Sabirats et al. (2014) document that, in Colombian municipalities, lack of access is frequently related to demand-side factors, such as economic and geographic barriers. As illustrated with data from Bogotá in Figure 5, people living in localities with lower income per capita are more likely to have worse health outcomes as well as lack health insurance. That said, despite the fact that the private insurance sector covers around 48% of the Colombian population (Minsalud, 2021), the *de facto* segmentation of the system is smaller because all insurers and providers are subject to a single financial and regulatory system. This contrasts, for example, with the case of Brazil, where health insurance coverage is *de jure* universal (Berlinski et al., 2020) but is in practice provided by a multiplicity of private and public insurance and providers, and where public facilities are governed by different geographic jurisdictions. In practice, Brazilian citizens, on average, incur larger out-of-pocket healthcare expenditures – around 13% higher than in Colombia (World Bank, 2021).

Figure 5: Income Per Capita and Health across Locations in Bogotá



Note: Localities (N=20) are weighted by their population. Localities include all neighborhoods (N=1,922). Bad health is measured as the proportion of respondents that described their health insurance service as "bad" or "very bad". Exercise is defined as the percentage of those surveyed who reported doing physical activity at least once per week during the last 30 days. No health insurance is measured as the percentage of individuals who report not being affiliated with any social security entity, either in the private sector (*contributivo*) or the public sector (*subsidiado*). All variables are taken from the Multipropósito Survey (SDP, DANE and Gobernación de Cundinamarca, 2017).

Regardless of the *de jure* fragmentation of the coverage system, proximity to medical professionals is systematically associated with better outcomes. For instance, in the United States, having twice as many doctors within 25 miles is associated with 6.26% lower mortality rates from heart diseases across counties, whereas the effect of having twice as many doctors within the band 25-50 miles around the county's centroid is of only 0.46% (Li, 2014). The likelihood of dying from a heart attack or unintentional injuries increases with distance to the closest hospital in Los Angeles, California (Buchmueller et al., 2006). Across Californian counties, increasing health expenditures by $10 is associated with a decrease in mortality of 9.1 deaths by 100 thousand people (Brown, 2014).

3.3 Cities and Healthy Lifestyles

Public infrastructure investments can shape urban lifestyles, constraining or enabling the ability of people to make healthy lifestyle choices (Smith et al., 2012). For example, in Brazil, Velásquez-Meléndez et al. (2013) find that the presence of parks and locations for physical exercise and other neighborhood characteristics are associated with a lower prevalence of overweight. In Colombia, the introduction of the TransMilenio Bus Rapid Transit (BRT) system of Bogotá was associated with an increase of 22 minutes a day of moderate-to-vigorous physical activity across socioeconomic groups (Lemoine et al., 2016).

Similar patterns have also been observed in other regions of the world. For instance, the rise of suburban life and loss of density in the United States – which was accompanied by a higher reliance on the automobile – has been linked to increases in obesity (Zhao and Kaestner, 2010). In the United Kingdom, switching *from* car to active commuting (i.e., walking or cycling) or to public transportation is associated with *decreases* in body mass index (BMI) of 0.3 kg/m^2, while switching *towards* car commutes corresponds to BMI *increases* of 0.32 kg/m^2 (Flint et al., 2016).

Healthy lifestyles can also be promoted through zoning policies and other planning tools. Urban planning can create urban environments favoring walkability, which has been linked to lower incidence of cardiopathies and hypertension (Su et al., 2017), and facilitate access to public health facilities, spaces for physical activities, and healthy food to disadvantaged socioeconomic groups, who typically face higher access constraints (Rossen and Pollack, 2012).

Experiences outside the region show that other local policies that seek to reduce unhealthy behavior can also be effective. Proposition 99, a large-scale tobacco control program implemented in 1998 in California, led to a 26-pack decrease in per capita cigarette sales by 2000 (Abadie et al., 2010). State-level cigarette taxes also achieved a reduction in consumption across the United States (Adda and Cornaglia, 2010).[3] When the city of Baltimore in the United States forced the relocation or closing of 76 liquor stores through a zoning ordinance in 2016, a significant reduction in violent crime followed in the neighborhoods where the stores were originally located (Stacy et al., 2020).

Similar policies have been implemented in Latin America, and many have shown to be effective. Policies that increase the price of cigarettes through taxes have decreased tobacco

[3]Not all state-level tobacco control policies were as successful. Public smoking bans, for instance, were associated with the unintended consequence of increased smoking in closed spaces, affecting passive smokers, children in particular (Adda and Cornaglia, 2010).

consumption in multiple Latin American countries (Guindon et al., 2018) and have been associated with reductions in medical expenses and increases in working years in Chile (Fuchs and Meneses, 2017). Likewise, regulations on cigarette packaging and marketing have increased smoking cessation during pregnancy in Uruguay (Harris et al., 2015).

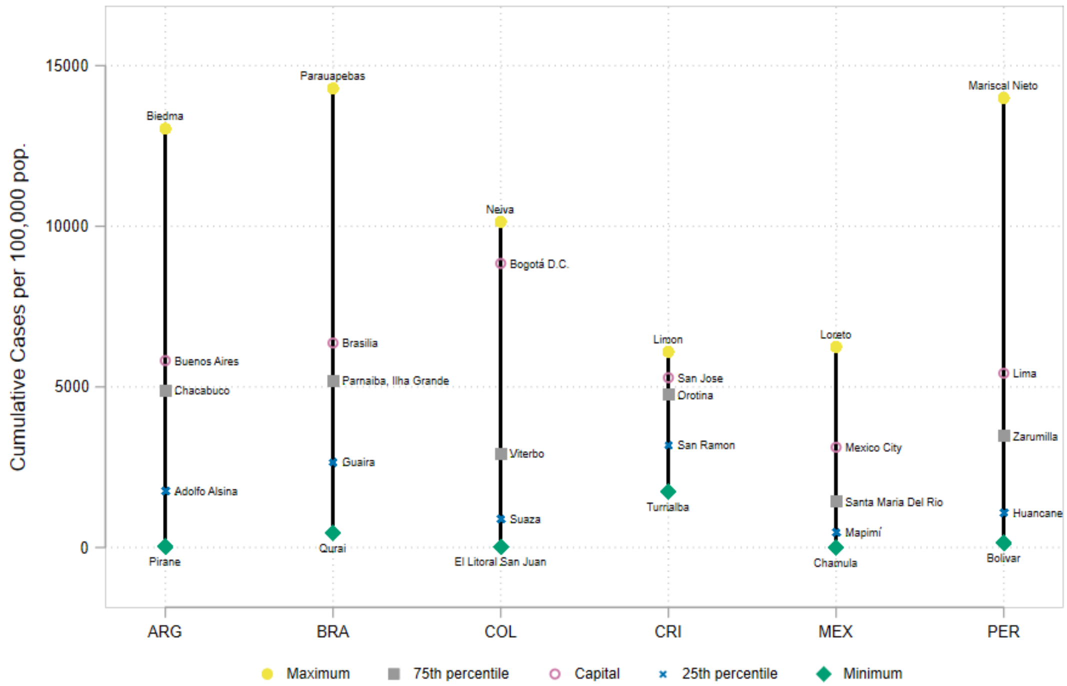
While many of these policies are typically implemented at the national level, local authorities can play a key role in enforcing them and in introducing additional initiatives for the promotion of healthy lifestyles at the local level. The *Muevete en Bici* program implemented in Mexico City, for example, was associated with an increase of 71 minutes per week in vigorous physical activity (Medina et al., 2019). Given the prevalent spatial health inequalities, such policies can have important re-distributive effects. The proportion of the population that exercise, for instance, is closely connected with average income at the neighborhood level (Figure 5). While richer neighborhoods are more able to privately provide spaces for exercising, such spaces are out of reach for many inhabitants of low-income areas, and local governments can make a difference through the provision of public parks and other open spaces.

4 The COVID-19 Pandemic and Latin American Cities

4.1 COVID-19 and Cities in Latin America

On February 26, 2020, the first confirmed case of COVID-19 was detected in São Paulo. Within weeks, the virus had reached all countries in the region. Early in the first wave, it became clear that the impact of the disease could vary substantively across cities within the same country. This is illustrated in Figure 6, which depicts the cross-city variation in confirmed cases per 100 thousand people for six Latin-American countries. With the exception of urban areas in Costa Rica, cities in the top quartile of the distribution tend to have a disproportionately higher incidence of cases per capita relative to the rest. In Argentina and Brazil, for example, the most affected cities of each country reported around 170% of the cases per capita of the cities in the 75th percentile. In Colombia, the worst-hit municipality had two and a half more cases per capita than those in the 75th percentile, and in Mexico and Peru this ratio corresponds to over three times as many cases.

Figure 6: COVID-19 Confirmed Cases per 100k People across Latin American Cities

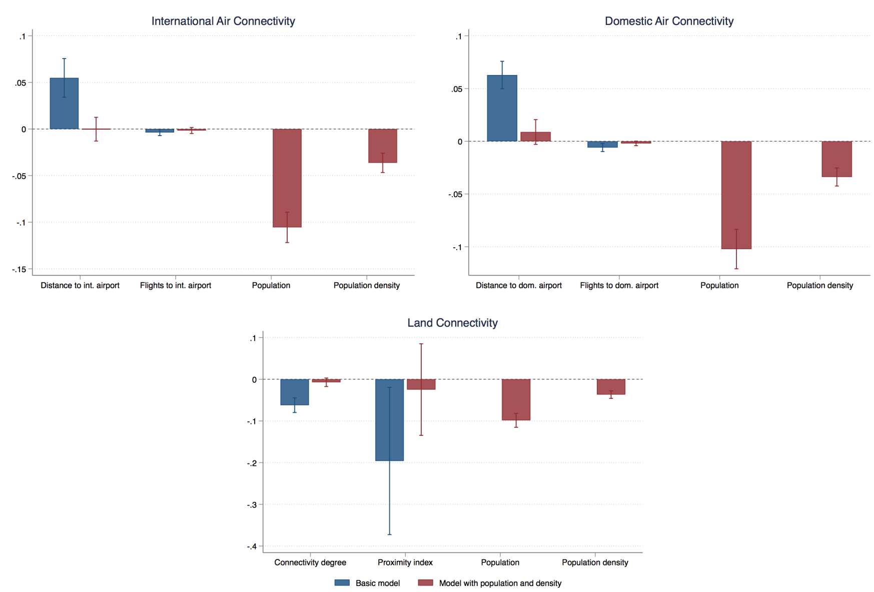


Note: Author's calculations with data from 1,904 Latin American cities with population of at least 10 thousand (240 from Argentina, 388 from Brazil, 615 from Colombia, 17 from Costa Rica, 463 from Mexico and, 182 from Peru). Cumulative cases until the latest available date per city. City definitions are not necessarily comparable across countries. They correspond to municipalities in Brazil, Colombia, and Mexico, departments in Argentina, cantons in Costa Rica, and districts in Peru. COVID-19 data is taken from: Ministerio de Salud de Argentina (2021), Brasil.io (2021), Datos Abiertos (2021), Ministerio de Salud de Costa Rica (2021), Secretaria de Salud de México (2021) and Ministerio de Salud de Perú (2021).

COVID-19 arrived first in the most populated cities, which are also the most interconnected, both nationally and internationally. In Brazil, for example, the first cases appear to have been imported from Northern Italy through international travelers arriving in cities with high international air traffic, in particular São Paulo, Rio de Janeiro, and Belo Horizonte (Candido et al., 2020). Figure 7 reports, for the Brazilian case, estimates the effects of different connectivity measures and city size on the number of days, since the beginning of 2020, that the city remained COVID-free. The first graph looks at two measures of international air connectivity: the distance to the closest international airport, and the distance-weighted number of flights that arrived to that airport in 2019. The base model unveils that cities located farther away from international airports remained without reported cases of the virus for a longer period. The same was true for cities exposed to fewer international travelers, and both effects are statistically significant. The second model adds to the regression population and population density as explanatory variables, finding large, negative, and significant effects of both, which indicates that more populated and denser cities reported their first case earlier. At the same time, when city size is considered, the effects of the international air connectivity measures shrink and become statistically not significant, consistent with the fact that international airports are located in or near large cities.

One caveat to the interpretation of the results above is the possible existence of reporting bias. The systematic under-reporting of COVID-19 deaths in Brazil and other regions of the world has been widely documented (Baqui et al., 2020; Cintra and Fontinele, 2020), and large cities with airports could have had earlier access to testing capabilities. However, there is no evidence that the undercounting of cases and deaths is systematically associated with income – at least at the country level (Goldberg and Reed, 2020), and studies of the geographic pattern of expansion of the disease within Brazil conclude that, even when considering potential measurement error, it is clear that large, highly connected cities acted as "super-spreaders" of COVID-19 to the rest of the country (Castro et al., 2021; Nicolelis et al., 2021).

Figure 7: Delays in COVID-19 First Confirmed Case and City Connectivity



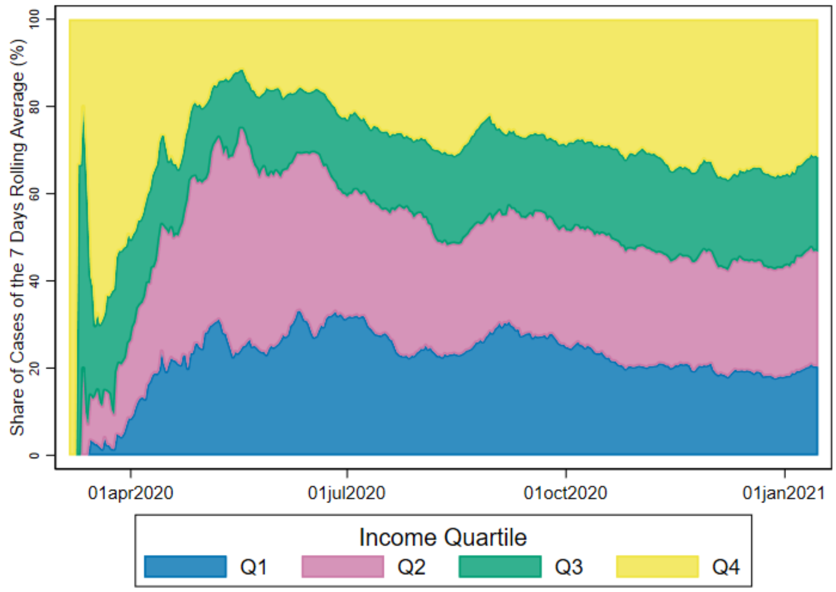
Notes: Author's calculations with data from 3,730 Brazilian cities with a population of at least 5 thousand from Chauvin (2021). Bars denote the estimated coefficients for each variable in a city-level OLS regression where the dependent variable is the logarithm of the number of days between January 1, 2020, and the day of the first confirmed case in the municipality. All regressors are standardized, and the regressions include state fixed effects. Lines denote 95% confidence intervals obtained from robust standard errors clustered at the state level. Air connectivity measures are constructed with the natural logarithm (Ln) of: distance to the closest international/domestic airport (in KM), number of international/domestic flights weighted by distance.

The second and third graphs in Figure 7 deal with the role of cities' domestic connectivity. The second figure recalculates the effects of air connectivity using domestic flights measures. The results are very similar to those of international connectivity, except that the small effect of domestic flights exposure remains statistically significant even after controlling for population. The last graph looks at two measures of land connectivity based on the existing road network and calculated by the Brazilian Institute of Geography and Statistics (IBGE, 2017): the number of cities with direct connection to the focal city ("Connectivity degree") and the inverse of the average distance to all other cities in the network ("Proximity Index"). Both variables have a strong positive effect in the base regression – showing that the virus arrived earlier in cities that were better connected by land – which shrinks and becomes not statistically significant once population and population density are considered – indicating that populated cities also tend to be those with greater road connectivity. Similar results have been reported by Fortaleza et al. (2020) and Nicolelis et al. (2021).

Within Latin American cities, COVID-19 first arrived in higher-income neighborhoods, where the destinations and places of residence of international travelers disproportionately concentrate. Figure 4 illustrates this pattern for Bogotá, plotting the share of total COVID-19 cases reported in localities belonging to different income quartiles. In late March and early April of 2020, the majority of all reported cases was concentrated in localities from the highest income quartile. However, within just a few weeks, the virus spread rapidly to the rest of the city, disproportionately affecting localities from the bottom two quartiles for most of the duration of the first wave. By the end of 2020, new infections were evenly distributed among localities with incomes above and below the median.

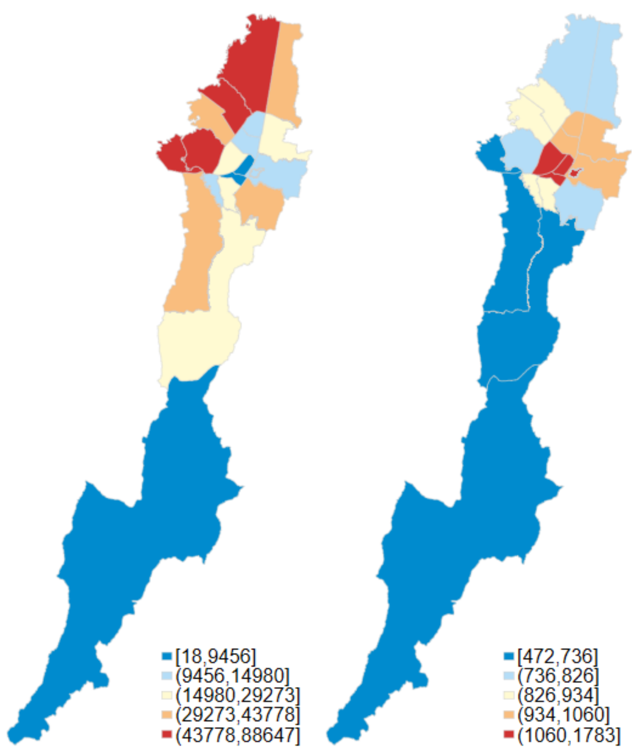
Figure 8: Impact of COVID-19 across Localities of Bogotá

Panel A: Spread of COVID-19



Panel B: Total COVID-19 cases as of Jan 31, 2021

C: Total COVID-19 cases per 10k as of Jan 31, 2021

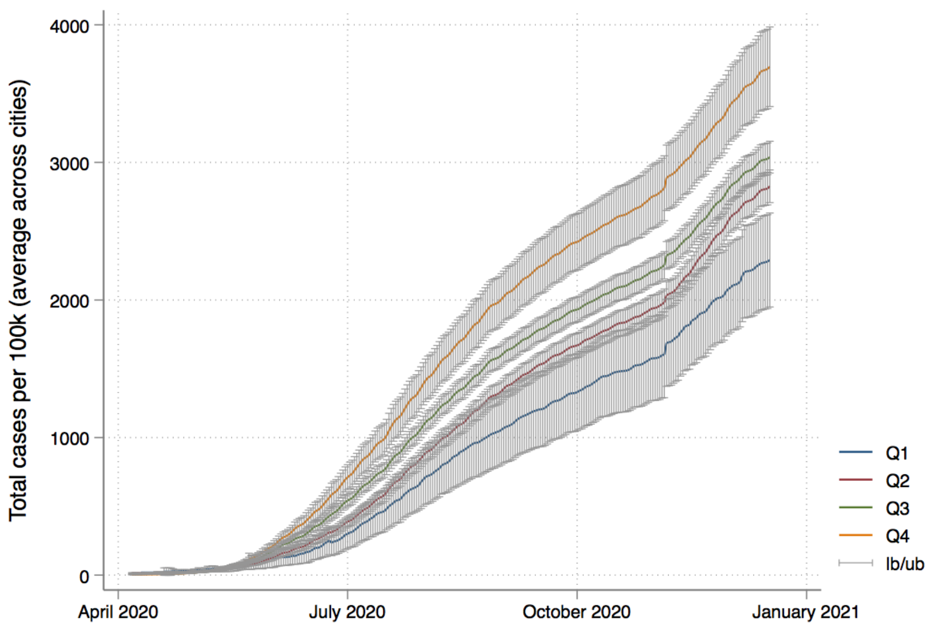


Note: Author's calculations using data from the 20 Localities of Bogotá. Localities include all neighborhoods (N=1,922). COVID-19 and income data are taken, respectively, from SALUDATA (2021) and the Multipropósito Survey (SDP, DANE and Gobernación de Cundinamarca, 2017). COVID-19 data as of January 31, 2021

4.2 Correlates of the Local Impact of COVID-19

The city characteristic most tightly linked to the impact of the pandemic is having a large population. COVID-19 arrived earlier and spread faster in large cities, which not only saw more COVID-19 cases and deaths in absolute terms, but also in per capita terms (Ribeiro et al., 2020). This is illustrated in Figure 9, which reports weekly averages and confidence intervals of COVID-19 cases per 100 thousand people in Brazil separately for cities in each population quartile. The figure further shows that the differences in per capita number of infections cannot be attributed to differences in the time of arrival of the virus to the city. During most of April, cities of different sizes were statistically indistinguishable in terms of the per capita impact of the pandemic. Over time, however, cities at higher population quartiles experienced faster growth in per capita infections.

Figure 9: City Size and the Impact of COVID-19 in Brazil

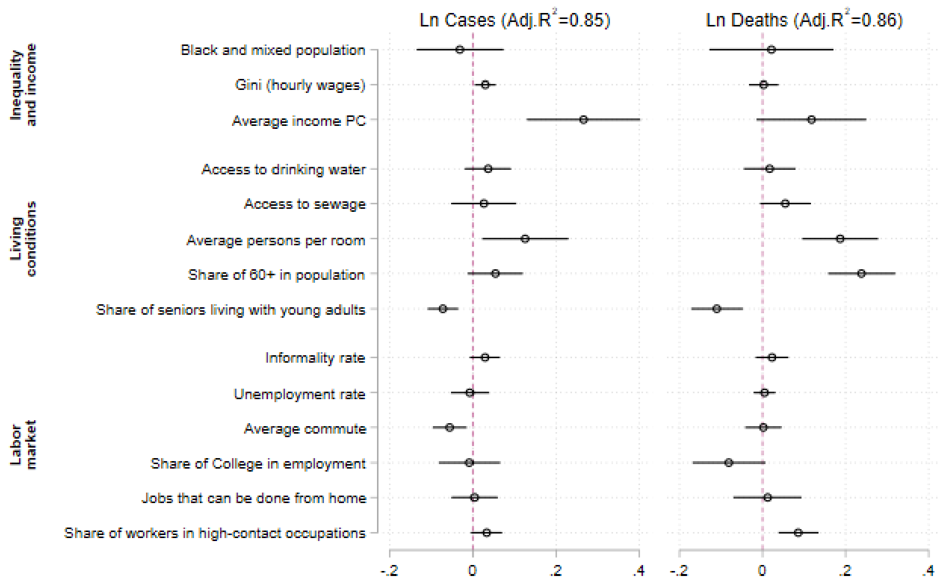


Note: Author's calculations with data from Chauvin (2021). The lines denotes the cross-city average within each population quartile from a total of 3,762 cities. The lines mark the lower and upper bound of 95% confidence intervals.

Nonetheless, the fact that COVID-19 affected some cities more than others cannot be fully explained by differences in their population. Indeed, the disparate geographic impact of the pandemic provides a vivid illustration of how multiple dimensions of socioeconomic spatial inequality shape health disparities across space. Figure 10 illustrates the effects of a wide set of variables on the cumulative number of COVID-19 cases and deaths per capita in 2,439 Brazilian cities from Chauvin (2021). Three groups of correlates are considered:

variables related to inequality and income, variables that capture the living conditions of the people of each city, and variables related to the labor market.

Figure 10: Correlates of the Local Impact of COVID-19 in Brazil



Note: Author's calculations with data from Chauvin (2021). Markers denote the estimated coefficients for each variable in a city-level OLS regression (N=2,439) where the dependent variables are, respectively, the total confirmed cases and confirmed deaths from COVID-19 in each city as of January 20, 2021. The sample is restricted to cities of population 10,000 or higher (N=2,439). Regressions also include as controls population – in order to interpret the coefficients in per capita terms –, population density, urbanization, measures of exposure to domestic and international air travelers, average number of days in the year with high temperatures, average yearly precipitation, internet access, the share of the population living in informal settlements, and distance to São Paulo. The regressions further control for baseline public health measures, including number of doctors, beds, ventilators, and the share of the population with at least one pre-existing condition associated with COVID-19 complications, as well as state fixed effects. The lines denote 95% confidence intervals from robust standard errors clustered at the state level. All regressors are standardized.

The figure shows us that by January 2021,[4] controlling for all other factors, cities with higher income levels had been relatively more affected by COVID-19, both in terms of number of cases and number of deaths per capita. This is likely linked to the availability of local work opportunities. Chauvin (2021) shows that, across Brazilian cities, median income was also associated with an earlier and consistently larger re-activation of local economic activity after the first few weeks of the pandemic, as captured by an increase in the share of people leaving their residences and moving around in their cities. Other

[4] Chauvin (2021) shows that the effects of city characteristics on local cases and deaths can vary over time. While the effect of some variables is consistent over the period of study, others that had a correlation with cases in the early days of the pandemic became uncorrelated over time, or changed the sign of their correlation.

studies have also linked the structure of the local economy with faster spread of COVID-19 and its economic toll (Ascani et al., 2021; Kim and Kim, 2021). The fact that higher median-income cities had more mobility and COVID-19 deaths does not necessarily mean that the these changes were concentrated among high-income individuals within those cities. If anything, existing evidence suggests the opposite. Brough et al. (2021) examine travel behavior within King County in the United States, and show that mobility declined much less among low-schooling and low-income individuals. This is also consistent with the fact that, as Figure 10 shows, cities with higher income inequality (as captured by the Gini coefficient) reported more cases per capita, holding all other variables – including income levels – constant.

The results for living conditions point to the importance of residential overcrowding for the spread of the disease (Ahmad et al., 2020; Desmet and Wacziarg, 2021; Hallal et al., 2020). Cities where households have a higher average number of persons per room experienced more cases and deaths per capita. Similar findings have been documented by Brotherhood et al. (2020), who show that in São Paulo and Rio de Janeiro areas with slums were associated with higher numbers of hospitalizations and fatalities. In contrast, access to piped water and sewage are uncorrelated with the local impact of COVID-19 after accounting for all other factors. Even though having older populations was associated with higher mortality – which is consistent with the fact that the absolute risk of death from COVID-19 grows with age (Davies et al., 2020; Dowd et al., 2020; Levin et al., 2020) – cities with a higher share of households where seniors and young adults cohabitate experienced fewer cases and deaths per capita, which may reflect the fact that, as multiple studies have shown, the presence of people with known vulnerabilities to COVID-19 tends to be associated with more preventive behavior in Brazil (Batista et al., 2020; Faria de Moura Villela et al., 2021; Lima-Costa et al., 2020).

Labor market variables, including informality rate, unemployment rate, average commuting time, and the share of jobs that can be done from home also appear to be uncorrelated with COVID-19 cases and deaths per capita holding other measures constant. Two features of the labor market that are uncorrelated with the number of cases but have a statistically significant association with the number of deaths are the share of people with college education (with a negative effect), and the share of workers employed in occupations that require high physical contact (with a positive effect). This suggests that in Brazil, as in the United States and other countries (Brown and Ravallion, 2020; Wiemers et al., 2020), workers with lower schooling levels and working in high-contact jobs may be more exposed the virus, and thus more likely to develop severe complications and die. They may also have relatively less access to timely health care services, which help mitigate the local impact of the pandemic (De Assis et al., 2021).

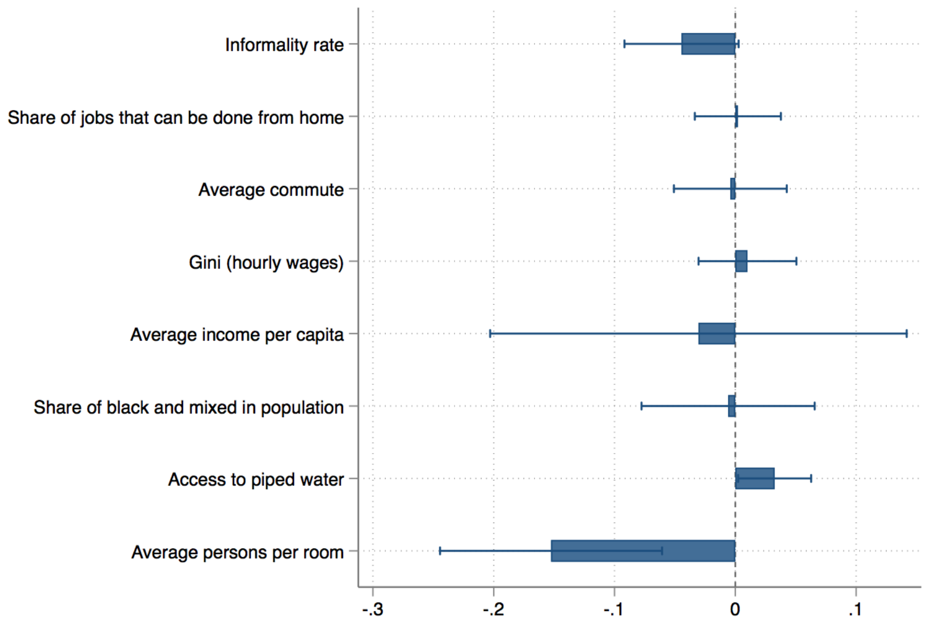
Some of the factors that made some cities more vulnerable to the COVID-19 pandemic than others also may have contributed to the fact that, relative to their rich-country peers, young and middle-aged adults in the region constituted a larger share of their country's COVID-19 deaths during the first year of the pandemic, even after controlling for the different age composition of the population (Chauvin et al., 2020; Demombynes, 2020). For instance, around 30% of deaths in Colombia were individuals younger than 60, compared to only 12% in the United States (Demombynes, 2020). Chauvin et al. (2020) use country-level and individual-level data to show that these differences in the age profile of COVID-19 deaths are partly explained by differences in the incidence of pre-existing conditions associated with severe complications from the disease, and by lower access to intensive care unit beds for young and middle-aged adults in developing countries relative to high-income countries. But they also show that there is significant variation in the deaths age profiles within countries, and that these differences are associated with city characteristics.

Figure 11 shows estimates of the correlation of different city characteristics with the mortality gap between the population aged 60+ and the population younger than 60, using data from Chauvin et al. (2020). A negative correlation implies that young and middle-aged adults in cities with a given characteristic represent a larger share of deaths than in cities without that characteristic. As the figure illustrates, controlling for all other variables, COVID-19 deaths among working-age adults were relatively higher in cities with higher informality rates, less access to piped water, and more residential overcrowding. This is in line with the work of Campos de Lima et al. (2021), who find that the high COVID-19 mortality in the large and relatively richer Southeastern cities of the country is partly explained by their relatively older populations, while cities located in the lower-income regions (North and Northeast) report higher levels of infections and deaths in younger populations, low-income families, and populations with limited access to healthcare. Other correlates of the local impact of the pandemic, such as income per capita, inequality (as captured by the Gini coefficient), and the share of ethnic minorities do not seem to have a differential impact by age group.

5 Concluding Remarks

The places where people live can make a big difference in their socioeconomic outcomes, and health is not an exception. Health outcomes can vary significantly across cities of the same country, and even across neighborhoods of the same city. In Latin America, a person's city of residence shapes multiple health outcomes, ranging from their exposure to illnesses

Figure 11: Correlates of the Gap between People Aged 60+ and People Younger than 60 in Their Shares in Total COVID-19 Deaths across Brazilian Cities



Note: Author's calculations with data from 1,386 Brazilian cities from Chauvin et al. (2020). Bars denote the estimated coefficients for each variable in a city-level OLS regression where the dependent variable is the difference of the shares in total COVID-19 deaths of the population aged 60+ minus the share of the population younger than 60. The regression also includes as controls the cities' population, population density, urban share, share of high-school and college-educated in employment, share of workers in high-contact occupations, extreme poverty rate, access to broadband, share of young adults living with elderly, share of elderly living alone, share of the population living in favelas, and measure of installed healthcare capacity (doctors, beds and ventilators), all measured before the first confirmed case in the country. The regressions also include state fixed effects. Lines denote 95% confidence intervals obtained from robust standard errors clustered at the state level. All regressors are standardized.

like malaria and other weather-related conditions, their access to water and sanitation, their ability to exercise and eat healthy, or how vulnerable they are to transmissible diseases like COVID-19. Furthermore, living in a poor and geographically isolated neighborhood may limit people's access to health services and expose them to more traffic congestion, air pollution and crime than other inhabitants of the same city. Internal migration, which could in principle help shrink spatial differences, has not been enough to close these gaps.

Health disparities across and within cities are tightly connected to other economic disparities. Economically disadvantaged populations, regardless of where they live, are more likely to suffer from multiple health risk factors, and overall poor health. At the same time, they are more likely to cluster geographically, frequently in places with limited public services located in the peripheries of cities. This increases their exposure to unhealthy living environments and limits their access to health services.

Spatial differences in health risks and outcomes were also features of the COVID-19 pandemic. Cities with higher population density and worse housing conditions, for example, suffered from more infections per capita than other series, at least during the first year since the first infection was reported. But despite the persistence of spatial disparities, COVID-19 also provided a stark example of the fact that local communities continue to be closely interdependent in their health outcomes. Even though infections were initially concentrated in only a few cities – particularly those with more transport connections with the rest of the world – in a short period of time the disease spread to most other cities. Within cities, the disease arrived first in higher-income neighborhoods, but it spread to lower-income neighborhoods within a few weeks.

Because many public health problems are local in nature, municipal and state policies are key to address them. Local governments can help not only by providing preventive and curative healthcare services in underserved and vulnerable communities, but also by creating public spaces where people can be active and develop healthy lifestyles; providing urban infrastructure like water, sewage and public transit; and creating incentives for people to avoid generating negative urban externalities.

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