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Comparing COVID-19 in the antipodes: Insights from pandemic containment strategies on both sides of the Pacific

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ABSTRACT

That the COVID-19 pandemic is unprecedented in terms of its scale, spread and shocks can be evinced by the myriad of ever-changing responses cities all around the world have rolled out throughout the different waves of outbreaks. Although the threat is similar across the world, it took some time before its reach became global and the waves of outbreak are experienced by cities at different times. While this staggered spread imply that some cities might manage the virus better as they learn from the experiences of cities which had been amongst the earliest to face the virus, the reality is more complicated. In the early stages of the pandemic, the global consensus on the best way to contain the virus swiftly converged in the interlinked strategies of restricting the movement of people and minimizing their social contact. However, the effectiveness of these strategies differ greatly between cities. To that end, this study focuses on COVID-19 responses in two regions (Latin America and Southeast Asia) and examines the evolution of the first wave of COVID-19 outbreaks during 2020 in Singapore, Jakarta (Indonesia), Bogotá (Colombia) and Santiago (Chile). The study is based on a comparative approach and uses a variety of data sources, namely morphology, density, housing concentration, mobility, and governance in the four analyzed cities. The goal is to shed light on the response of city governments in these two different regions in terms of mobility restrictions in order to reduce the cases of new infections. The results show the relevance of urban policies and their territorial approaches, particularly in terms of mobility and public transport networks in the four cities.

1. Introduction

Since the beginning of the COVID-19 pandemic, there have been profound and radical changes to people’s daily lives globally. These changes continue to unfold every day and several studies have described not only the characteristics of the pandemic but also its effects on different geographical scales and thematic areas. The severe lockdown measures experienced by most countries seem to be fostering the increased adoption of sustainable mobility (Vecchio et al., 2021). This has resulted in renewed discussions about mobility styles and the way passengers perform their everyday tasks (Abou-Korin et al., 2021). The observed reduction in daily mobility patterns compared to pre-COVID-19 times has been attributed to a combination of reduced usage of public transport and increased usage of both cars and active...
transportation modes such as bicycling and walking (Corazza et al., 2021; Schmidt et al., 2021). Moreover, to ensure the effectiveness of social distancing, countries around the globe have seen rapid changes in how street space is allocated, designed, planned, and funded (Combs and Pardo, 2021).

Although the health crisis has indiscriminately affected all segments of society and sectors across the globe, there is a differentiated understanding of the role of mobility and socio-economic inequalities on the pandemic’s impact on a regional basis. While it is well known that the density benefits mobility and accessibility, particularly in encouraging the active use of public transport (Choi et al., 2020), there is inconsistent evidence regarding the effect of population density on the spread of the virus. On the one hand, early studies have indicated that high-density areas can explain the COVID-19 infection rate in, for example, countries in the Americas such as the United States (Andersen et al., 2021), Brazil (Viezezzer and Biondi, 2021) or Mexico (Benita & Gasca-Sanchez, 2021). On the other hand, studies conducted in Asia have presented counterexamples of densely populated areas in which the number of infections caused by COVID-19 is no different from that of cities with low urban density, particularly in China (Chen et al., 2021) and Hong Kong (Kan et al., 2021). Mandatory lockdowns are probably likely to deepen already significant social gaps between the poor and the rest of the citizens in vulnerable societies without formal livelihoods and social security (Renahy et al., 2018).

Despite the abundance of research, comparative studies at the city level are scarce. Even though the pandemic offers an unprecedented opportunity for comparative research, as virtually every city is facing a common catastrophe one after another, studies comparing geographically distant cities are scarcer still (Sharifi & Khavarian-Garmsir, 2020; Combs and Pardo, 2021). This study aims to fill this research gap by carrying out a comparative study between cities in Southeast Asia and Latin America.

The comparative analysis is based on data from Google Mobility Reports, TomTom Traffic Index, and official government sources. This work looks at the experiences of Singapore, Jakarta (Indonesia), Bogotá (Colombia) and Santiago (Chile), comparing the scope and success of the measures implemented by their governments to slow the spread of the virus during the first wave in early 2020. The focus is on reviewing the policies of city governments aimed at curtailing mobility (Baldasano, 2020; Dantas et al., 2020); investigating the extent to which structures/urban morphology affect the control of the virus (Kihato & Landau, 2020), and the difference good governance makes in managing the pandemic (Elkington, 2006; Lieberherr-Gardiol, 2008; Rice and Hancock, 2016; Krzyztofik et al., 2020; Steele, 2020). The relevance of the article is based on proposing a comparative study of four cities with similar territorial characteristics, but geographically distant or the antipodes from each other: Singapore and Jakarta (Indonesia), both located in Southeast Asia; and Bogotá (Colombia) and Santiago (Chile) in Latin America. Thus, by appealing to the idea of antipodes, the authors propose a comparison of two regions that have many similarities in terms of urban growth in the last four decades, but with differences in the reaction capacity of local governments in the context of the pandemic.

2. Relevant literature

2.1. Comparative studies on COVID-19

The impact of the pandemic has been profound, radical, and is arguably one of the most serious crises in human history (Ocampo, 2020; Sharifi & Khavarian-Garmsir, 2020; Duggal, 2020). Since the beginning of the outbreak, its effects have been present in everyday life and it is very difficult to imagine any place in the world free from the pandemic’s health or economic effects (Ocampo, 2020; Sharifi & Khavarian-Garmsir, 2020). Various studies in the world have analyzed the impacts of the pandemic and how supranational institutions and governments have struggled at different levels to confront this persistent, invisible, and unpredictable menace (Lu et al., 2020; Thoi, 2020; Duggal, 2020; Rahman, 2020). COVID-19 different indicators have been considered and analysed in terms of the effects of the current crisis (Sharifi & Khavarian-Garmsir, 2020; Moynul, 2020; Prieto et al., 2021), either to address health issues (Harapan et al., 2020; Bilal et al., 2021), socioeconomic issues (Kan et al., 2021; Chen et al., 2021; Gozzi et al., 2021), mobility and transport (Baldasano, 2020; Benita 2021; Zangari et al., 2020; Rahman, 2020; Rashmawati et al., 2021), built environment (Megahed and Ghoneim, 2020), public policies (Duggal, 2020; Bakir, 2020; Bennett, 2021), environmental issues (Sharma et al., 2020; Rizky et al., 2021), or, compare territorial realities that support their analysis at different geographical scales (Sharifi & Khavarian-Garmsir, 2020; Ocampo, 2020; Moynul, 2020).

The latter is of the highest relevance, since comparative studies at the urban scale analyse the effects of the pandemic on the role of governance and its link to sustainability (Elkington, 2006; Lieberherr-Gardiol, 2008; Rice and Hancock, 2016; Krzyztofik et al., 2020; Steele, 2020). They include analyses of urban structure and morphology, addressing existing social and economic inequalities (Kihato & Landau, 2020; Moynul, 2020; Prieto et al., 2021), as well as mobility restrictions and effects on transport, particularly by improving urban air quality in European (Baldasano, 2020) and Latin American cities (Dantas et al., 2020), or adjusting daily travel patterns and activities (Rahman, 2020; Guzman et al., 2021). Similarly, interesting comparative studies among cities conducted in Europe have pointed out possible structural changes in land use where demand for real estate in central areas has progressively fallen in favor of less expensive and dense peripheral areas (Corazza et al., 2021). Here, intra-city connection through public transport appears as one of the most significant factors contributing to the spread of the virus (AbouKorin et al., 2021).

Southeast Asia and Latin America share common and intertwined interests in politics, security, and social affairs. Even though they are dissimilar in culture, political governing systems and history, the two regions share important similarities in terms of their population density, various types of land use mixes, including horizontal, vertical, and temporal forms, as well as the challenges they face nowadays. (Kihato & Landau, 2020; Prieto et al., 2021; Rizky et al., 2021). We recognize inconsistencies of urban form characteristics between and among the surveyed cities, regardless of geographical region. However, by observing how population density both in Southeast Asia and in Latin America has been decreasing periodically might indicate that they are undergoing similar urban development processes.

The pandemic has created a natural experiment of unprecedented proportions to compare cities. It has been possible to observe and quantify common reactions of residents and local authorities in responding to a health crisis. For example, in an effort to document the quick reactions (specifically in terms of changing mobility demand) to the COVID-19 pandemic, Combs and Pardo (2021) present a database of documents with timeline responses in 524 regions around the world. Nonetheless, there is little evidence comparing the effects of the pandemic between cities. This is even more so for distant urban contexts with urban realities that are in many cases dissimilar. According to Sharifi & Khavarian-Garmsir (2020), studies that have attempted to make comparisons so far have not sufficiently accounted for the particular conditions of cities. The comparative approach is also hindered by methodological complexities such as scale of analysis and territorial contexts. Suffice to say, a single variable can affect any proposed analysis framework. Notwithstanding these challenges, existing studies argue how the spread of the pandemic in cities is influenced by factors such as the urban environment/morphology, management and governance of the city, urban design and transport, and the socioeconomic characteristics of the population (Sharifi & Khavarian-Garmsir, 2020; Benita & Gasca-Sanchez, 2021).

While these factors are clearly relevant in explaining the spread of the pandemic in a given city, only through a comparative analysis of
several cities would we obtain a more granular understanding of the relative importance of these factors and equally importantly how they might be reconfigured to stem the spread of the virus instead of fanning its spread. To that end, we propose a comparison of two regions that have many similarities in terms of the history of their urban growth, analysing the cities of Singapore and Jakarta (Indonesia), both located in Southeast Asia; and Bogotá (Colombia) and Santiago (Chile) in Latin America. These four capital cities have experienced continuous urbanization in recent decades, share a comparable number of inhabitants, and face varied challenges in their transport system, such as growing traffic congestion, overwhelmed public transport systems, and worsening accessibility gaps. However, they notably differ in their population density distribution and political organization. More on the similarities and differences will be described in the following sections of this paper.

2.2. Selected cities

Bogotá is a compact city (380 km² of urban area and 7.4 million inhabitants) whose main public transport system was designed to connect the densely populated areas of the periphery with the eastern border, where employment is concentrated. Many informal neighbourhoods emerged on the outskirts of the city with poor urban living conditions, where density reaches 70,000 inhabitants/km² (Guzman et al., 2021). Low-income populations depend on non-motorized transport and public transport for daily trips, with around 61% and 28% of modal share respectively. They travel more than an hour per trip on public transport. This is due to their low motorization rate and the location of their homes on the urban periphery far away from activity centres. The first case of the COVID-19 registered the city was on 6 March 2020, and by early 2021, the number of reported cases had surpassed half a million— a testament to the rapidity at which the virus was transmitted.

Singapore, with barely more than 710 km² is home to roughly 5.69 million people. The core rationale of the city’s planning is to optimize use of the country’s scarce land resources for current and future generations. Space in Singapore is meant to function as the most valuable resource for its highly specialized but increasingly aging society. One way to address gaps resulting from such demographic imbalance while securing its economic viability is to rely on foreign workers. Even though the government has periodically imposed quotas to moderate imported human labour. According to Singapore’s Ministry of Manpower, 2021, in 2020, foreign workers numbered more than 1.64 million, roughly 29% of Singapore’s total population. Since the 1950s, the city has urbanized rapidly. Consequently, today, 100% of the city’s population can be considered “urban” (United Nations, 2018). In Singapore, like perhaps most of its regional counterparts, the virus arrived on an inbound flight. The case, a 66-year-old male Chinese national, came from Wuhan on 20 January 2020. The following weeks Singaporeans lived in a climate of tension and unease as the government scrambled to maintain a basic sense of normalcy amid a regional outbreak.

Santiago is the capital city and the most important urban area of Chile. According to 2017 census data, the Metropolitan Area of Santiago is home to 7,036,792 people, which is equivalent to 40.5% of the total national population (National Institute of Statistics of Chile, 2017). Administratively, this urban area comprises 34 communes (local scale governments), which depend on a regional government, whose jurisprudence covers the entire Metropolitan Region. The city has historically presented high levels of urban segregation, and a recent urban development strongly influenced by the neoliberal public policies implemented in the country during the 1970s by the military dictatorship (Puentes & Rodríguez, 2020). This segregation is also influenced by the multiple urban highways splitting the city in some areas (Vassallo et al., 2020) and observed in the socio-economical characteristics of the millions of passengers using the fare-integrated bus and metro services (Muñoz et al., 2014). Once the first case of contagion was detected in Chile, different institutions such as schools, companies and organizations had their activities halted. On March 18, 2020, President Piñera decreed a state of constitutional emergency, establishing measures of control and social order, as well as an economic plan equivalent to 4.7% of the national GDP to safeguard the chain of production and distribution of essential goods and services, protect employment, and boost the economy.

Jakarta is a microcosm of diversity and complexity. It is itself within a complex universe made of islands, cultures, and traditions. The epicentre of this urban centre sprawling over roughly 6343 km² and encompassing four other cities in two provinces in the northwesternmost part of Java, is the Special Capital District of Jakarta, referred to by its Indonesian acronym DKI. As has happened with other megacities, Jakarta has been compared to different urban models, some not necessarily compatible with its permanently shifting morphology that is subject to dichotomies that are formal and informal, planned, and organic. Hence, perhaps, Jakarta and its metro area have a population density of around 13,000 people per km² (Martínez & Mason, 2020). The origin of the COVID virus in Jakarta is still disputed. In the aftermath of the Wuhan outbreak, the Indonesian government had taken several precautions, e.g., evacuating students from Wuhan and quarantining them in Natuna Island for 14 days, cancelling direct flights from China to Indonesia, monitoring the temperature of people coming into Indonesia at ports and airports, and testing suspected subjects.

3. Methods

Mixed methods research, as the collection and analysis of both qualitative and quantitative data and its integration is the framework adopted in this work. Our attention is on the periods before, during, and after lockdowns with the aim of describing associations between mobility patterns and confirmed cases of COVID-19 and deaths in the selected cities.

On the one hand, by following the method of Structured Focused Comparison (SFC) proposed by George and Bennett (2005) we focus on causal mechanisms rather than causal effects (Gerring, 2006: 37). SFC has a pre-established set of questions focusing on the underlying process, on the causal nexus between dependent variables (cases of COVID-19 and deaths) and independent variables (urban characteristics, proxies for mobility and governance). We proceed with the harmonization of a wide range of secondary data sources, such as scientific articles, government and non-governmental organizations’ reports, datasets and newspapers. With respect to the independent variables, we consider a variety of urban characteristics such as population density (inhabitants/km²), household crowding (percentage of homes that have overcrowded conditions), households with poor-quality construction materials (percentage), average monthly income per person (USD), workforce (percentage), life expectancy (years), average years of schooling, population aged 65 years and above (percentage), particulate matter (PM 2.5) and green space (hectares).

We further focus on sustainable mobility and governance characteristics of the four cities. Mobility data is retrieved mainly from Google COVID-19 Community Mobility Reports. These reports contain travel time data collected from smartphones with built-in GPS sensors. The dataset in effect measures visits to different locations, some of them are considered essential everyday trips (e.g., grocery, pharmacy, supermarket) and compares this change relative to a baseline day before the pandemic outbreak. According to the company, baseline days represent a normal value for that day of the week, given as the median value over the five-week period from January 3rd to February 6th, 2020. Measuring it relative to a normal value for that day of the week is a useful strategy as people commonly change their routines on weekends versus weekdays. We present Google’s data though effective visualizations and tables to make it simpler to see the changes over time in the four studied cities and, specifically, how policies dictated by local governments may have informed (or not) the spread of the virus. To be sure, changes in
Fig. 1. Space-temporal propagation COVID-19 in Santiago (upper panel), Bogota (middle panel) and Jakarta (bottom panel). Note: The Ministry of Health, Singapore does not disclose geographically detailed cases information limiting the space–time reconstruction of infections.
traffic stats portal. This is a congestion index that measures levels of TomTom historical traffic data that was extracted from the TomTom

Table 1
Timeline of the first wave of COVID-19 epidemic.

| Event                  | Bogotá       | Jakarta      | Santiago     | Singapore  |
|------------------------|--------------|--------------|--------------|------------|
| Cumulative cases       |              |              |              |            |
| First case             | 6-Mar-20     | 3-Mar-20     | 4-Mar-20     | 23-Jan-20  |
| 100 cases              | NA           | 17-Mar-20    | 16-Mar-20    | 29-Feb-20  |
| 1,000 cases            | 7-Apr-20     | 4-Apr-20     | 28-Mar-20    | 1-Apr-20   |
| 10,000 cases           | 30-May-20    | 23-Jun-20    | 1-May-20     | 22-Apr-20  |
| 100,000 cases          | 30-Jul-20    | 20           | 6-Jun-20     | —          |
| 200,000 cases          | 25-Aug-20    | 8-Jan-20     | 6-Jul-20     | —          |
| 300,000 cases          | 17-Oct-20    | 9-Feb-20     | 14-Jan-20    | —          |
| PCR Tests              |              |              |              |            |
| First tests            | 24-Feb-20    | 29-Feb-20    | NA           | 7-Apr-20   |
| 100 tests              | NA           | 3-Mar-20     | NA           | 7-Apr-20   |
| 1,000 tests            | 20-Mar-20    | NA           | 7-Apr-20     | —          |
| 10,000 tests           | NA           | 6-Apr-20     | 11-Apr-20    | 7-Apr-20   |
| 100,000 tests          | 31-May-20    | 14-May-20    | 4-May-20     | 15-Apr-20  |
| 200,000 tests          | 20           | 20           | 20           | 4-May-20   |
| 300,000 tests          | 10-Jul-20    | 27-Jun-20    | 28-May-20    | 18-May-20  |
| 500,000 tests          | 08 Aug-20    | 22-Jul-20    | 15-Jun-20    | 8-Jun-20   |
| 1,000,000 tests        | 16 Sept-20   | 8-Sep-20     | 13-Aug-20    | 10-Jul-20  |
| Deaths                 |              |              |              |            |
| First death            | 21 Mar-20    | 3-Mar-20     | 22-Mar-20    | 21-Mar-20  |
| 100 cases              | 30 Apr-20    | 4-May-20     | 28-Apr-20    | —          |
| 1,000 cases            | 10 Jul-20    | 17-Aug-20    | 4-Jun-20     | —          |
| 10,000 cases           | 04 Jan-2021  | —            | 9-Nov-20     | —          |
| 100,000 cases          | —            | —            | —            | —          |

Note: “NA”: Not available. “—”: Not reached after the first wave.

daily and weekly congestion, with each week starting from Monday and ending on Sunday. Among the considered governance independent variables, we have total number of PCR test, mandatory quarantine (days), number of vaccines authorized, number of government websites providing information on COVID-19, number of government press conferences, number of tax breaks for small and mid-size enterprise (SME) businesses, and number of SME loans. We also performed pair-wise t-test to investigate the differences in temporal workplace and residential mobility patterns between different cities.

Lastly, we present our main findings in the form of an effective visualization dashboard that can be used as a decision-support tool within the public health sector. Interactive dashboards have shown to effectively address the need of different stakeholders for analysing multidisciplinary data from different sources, all linked to the COVID-19 pandemic (Dong et al., 2020). Intuitive and interactive dashboards are helpful for updated analysis and visualization of mobility indicators not only for general public but also for policymakers, government agencies or corporate research firms who do not necessarily possess technical skills to automate tedious tasks of data collection and representation. Also, dashboards can generate awareness about case trends, tracking and monitoring which are useful for public health decision making (Ivankovic et al., 2021).

4. Results

4.1. Covid-19 timeline: A brief comparative review

As depicted by Fig. 1, we can observe the spread of the virus through the first wave at three strategic cut-off points, namely, before (Phase 1), during (Phase 2), and after the lockdown (Phase 3). Note that spatially aggregated data of new infections in Singapore is not available. By visual inspection in the case of Santiago (Fig. 1 upper panel), we observe a spatial spread pattern from hotspots in the wealthiest north-eastern districts and central areas of the city towards hotspots in the peripheral parts of the city by the end of Phase 3. In Bogota, the spread of contagions developed from the north to the centre and west of the city, indicating the latter as districts with the highest number of contagions. In Jakarta, there is a spatial pattern characterized by a greater number of contagions in the western sector of the city, and then moving to the central and eastern area.

Table 1 lists a timeline of how COVID-19 cases, deaths and PCR tests evolved during the first wave in 2020. It is worth noting that Bogota reached 300,000 cases faster than the rest of the cities. The number of cumulative deaths is significantly smaller in both Asian cities than in the Latin American cities. This may be associated with the attitude of the
Fig. 2. Comparative analysis among cities. Dashboard visualization.
Latin American population of not being affected by the virus (Ocampo, 2020). Interestingly, the rate at which PCR tests were applied are quite similar between Bogota and Jakarta and between Santiago and Singapore, while the latter two tested significantly faster than the former ones. Table 2 shows the policy responses across the four cities. While Singapore deployed one eight-week lockdown only, the mobility restriction measures were enforced more frequently and for longer periods of time than Santiago. We also observe that Jakarta and Singapore introduced early economic stimulus packages to support economic activity. All in all, lockdown measures, social restrictions and governance measures look similar among all four cities with the difference being that in Southeast Asian cities they were implemented earlier. To further investigate differences among the four cities, Table A1 in the appendix shows detailed information regarding the main socio-economic features, mobility patterns and government efforts to manage the COVID-19 pandemic. To better understand the interactions among variables in the next section we further elaborate interesting findings supported with visualizations.

4.2. Measurements and changes in mobility patterns

Bogotá. Public transport is the most used mode in Bogotá. The Bus Rapid Transit system, commonly known as BRT, and regular buses comprise the public transport system in the city with a share of 39% of daily trips (before the pandemic). Based on the state of emergency declaration due to the rapid growth of COVID-19 in the world, the National Government issued Executive Decree No. 482 of 26 March 2020 to take measures on the provision of public transport services. The decree adopted mobility restrictions and mandatory preventive isolation, reducing the supply of public transport services up to 50%. These measures had an important effect on mobility at the city level causing substantial changes in people’s mobility and activity patterns (Guzman et al., 2021). Also, mobility for recreation activities and to retail destinations diminished around 50%. Work-related trips showed a reduction of around 60% and the congestion level was between 60% and 80% of a typical day (Arellana et al., 2020). However, these changes have not been equally distributed across different income groups, negatively impacting the lowest-income inhabitants. Almost 40% of the citizens could not carry out their main activities at home. About 58% of the low-income population stated that it was impossible to perform their activity from home, while 24% and 11% reported the same for medium- and high-income groups, respectively (Guzman et al., 2021). Therefore, this highlights inequalities regarding the accessibility to opportunities of lower-income groups and the inadequate provision of transport systems.

Jakarta. The so-called ‘large-scale social restrictions’, over the eight-week period, was imposed by local authorities during the first lockdown enforced closure of educational institutes, commercial areas, tourist attractions and many other public spaces that could potentially attract public gatherings. According to the COVID-19 community mobility reports (2020), the transportation activities in the city during the lockdown period dropped 66%. Interestingly, there is some evidence that although teleworking or e-learning tended to increase during the outbreak, the travel frequency of residents remained unchanged. In other words, a person who could work or study from home kept travelling with a lower trip frequency for those trip purposes. Moreover, our results suggest that both Santiago and Jakarta exhibited similar volumes in their weekly reduction in visits to workplaces. With respect to the link between mobility reduction and the virus transmission, there is evidence (Wijayanto & Wulansari, 2021) that weeks with larger volumes of movements to “Retail and Recreation”, “Grocery and Pharmacy” and “Parks” were positively associated with larger number of COVID-19 cases.

Santiago. The first cases of COVID-19 appeared in Santiago in early March 2020. They were mostly Chileans arriving from their holidays abroad. As Santiago is a very segregated city, in which most affluent citizens live in its north-eastern area, the first cases were concentrated in this zone. However, since this group also has access to the best health services in the city, the pandemic accelerated its death toll only when the virus spread to the rest of the city. The government tried dynamic confinements per city district, in which areas of the city were forced to remain in their districts, while residents from other areas could move around more freely. Mobility experienced an abrupt decline as soon as these constraints were implemented in late March and stayed quite low for around three months. In early July, flows began to grow slowly but steadily during 2020. Although this pattern was shared by both automobile traffic and public transport trips, the former recovered at a much faster pace. By the end of the year, car flow was slightly lower than a year earlier while public transport was slightly above half its usual volume. By the end of 2020, the second COVID wave hit, affecting mobility in the city for the whole first half of 2021. However, its drop was not as strong as the one observed in early 2020. Unfortunately, the public transport system has struggled to recover to its pre-pandemic demand level even though the agencies have tried to keep frequencies at their former levels. In addition, we observe a sizable increase in the “Residential” activities, which are associated with the increase in telecommuting and the quarantines. Interestingly, we observe that in Santiago the reduction in this type of activity after the initial wave has been slower than in the rest of the cities, which might indicate that activities done from home might persist more than in the other studied cities. Finally, it appears that bicycle share among urban trips has kept growing during the pandemic. Bike trips had been growing quite significantly during the previous decades, and confinements appear as a new reason to turn towards the bicycle since it appears as a mode that is safe from contagions.

Singapore. From Fig. 2, we observe that both public and private mobility largely reduced due to the severe restrictions imposed during the lockdown. Interestingly, the change (increase) in “Residential” activity during the outbreak was similar to the one reported in Jakarta. Singapore was the sole city in our sample in which measured PM 2.5 concentrations increased during the lockdown period. The drop in PM 2.5 concentrations was only seen after the mobility restriction measures. This is indicative of the potentially small contributions of traffic emissions to outdoor pollutants. In respect to the relationship between changes in human mobility and cases of COVID-19, the link is complex. For instance, the early study of Jiang et al. (2021) found evidence that there is a lag (non-linear) effect of changes in car mobility and cumulative confirmed cases.

From the upper panel of the dashboard of Fig. 2, we can see that demographics in Santiago and Singapore are comparable in terms of age, population, population density and life expectancy. Likewise, notable demographic similarities between Bogota and Jakarta can be observed. Interestingly, Jakarta was the only city showing that air quality got worse even after a lockdown was established. This finding has been documented by Jakob et al. (2022), arguing that although human mobility and economic activities decreased during the lockdown, rainfall can explain the observed increase in PM 2.5 concentration. Therefore, comparing air quality pre- and during lockdown is misleading when seasonal variation and meteorological variables are not taken into account.

When looking at the similarities and disparities in terms of mobility between these four cities, bar charts “public transport mobility” and “private vehicle mobility” of Fig. 2, interesting insights are worth highlighting. In terms of public transportation ridership changes, we observe for all cities a marked decline and an increase to almost 20% during the lockdown period. This fact might be evidence of how some labour force characteristics are shared between these cities, as it seems that a similar number of people was required to continue travelling during the lockdown, probably because of the nature of their jobs. The differences however are evident when looking at the before and after picture of lockdown periods. All the cities but Santiago had a similar and significantly higher public transportation ridership before the lockdown. One possible reason is the existence of the partial lockdowns before the
complete lockdown during the months before. Regarding ridership after the lockdown, we observe different public transportation ridership recoveries, which might be related to the success of the lockdown and the overall pandemic situation in the immediate months after that period. However, our study is not conclusive about the facts that might explain such differences at this stage.

With regards to the mobility dynamics in workplace, residential, and retail and recreation, the bottom panel of the dashboard of Fig. 2 shows daily mobility of people with data from the Google Community Mobility Report. We observe that work and retail-and-recreation trips changes were steep in all cities during the initial months of the pandemic. The mobility recovery was noticeably faster for Singapore and followed by Bogotá, which had an intermediate lockdown around August. In addition, when looking at Santiago, we notice that the reduction of work trips and its persistence is aligned with its more permanent increase in residential activity. This might be evidence of a higher penetration of telecommuting in this city. Jakarta, on the other hand, shows the least pronounced mobility changes which stabilized by the end of 2020. The next subsection elaborates further on changes in mobility trends.

4.3. Statistical analysis of mobility trends

Using Google Mobility data, we employ a t-test on the mean mobility pattern differences for each pairwise city combination. This is a country-to-country comparison of pre-, during- and after lockdown. Our focus is on the evolution of workplace and residential mobility, as displayed in Table 3. Meanwhile Bogotá, Santiago and Singapore showed similar mean levels of workplace mobility during the pre-pandemic period, Jakarta exhibited different patterns. In other words, Jakarta citizen’s workplace mobility before the pandemic was not comparable to these of the other three cities. Interestingly, we also notice that during the pre-pandemic period, residential mobility is comparable only between cities from the same continent as the mean levels of residential mobility are different for Bogotá-Singapore (p-value = 0.078), Jakarta-Santiago (p-value = 0.086) and Santiago-Singapore (p-value = 0.016).

As expected, when looking at the pandemic and transition periods in panels B and C of Table 3, workplace and residential mobility were severely affected. On the one side of the spectrum, in Bogotá and Santiago, these mobility changes could be explained not only by the adopted lockdown policies but also by public health policies earlier adopted and maintained with high degrees of stringency in their implementation. For example, the study of Martinez-Valle (2021) showed that, compared other cities in Latin America, Bogotá and Santiago not only had better communication from their governments by implementing swifter and more strict public information campaigns but also had stronger social protection systems in place before the outbreak, including better health system indicators. On the other side of the spectrum, compared to other provinces in Indonesia, Jakarta imposed stricter reduction mobility measures from September to November 2020 which could have the large variation of mean mobility values on Table 3 when compared to other cities. By using the exact same mobility dataset, the study of Khoirunurofik et al., (2022) documents the significant decreased aggregated mobility in Jakarta as compared to other cities and regencies in Indonesia.

4.4. Urban structure and COVID-19 transmission

From the analysis we have carried out we can interpret that the urban structure and morphology of the cities analysed is a factor of great relevance in the spread of the virus. Among the different characteristics of cities, there are some aspects that act as a central axis in terms of urban morphology and are associated with the increase in infections, and, therefore, the spread. These aspects are related to the unequal structure of cities, in social and economic terms (Kihato & Landau, 2020; Valenzuela-Levi et al., 2022). These include peripheral areas marked by poverty and marginality, urban facilities, and poor access to transport (Valenzuela-Levi et al., 2021); and high-income areas, with better access to urban facilities, among other variables (Méndez et al., 2021; Fuentes et al., 2020).

Thus, in the cases of Jakarta and Bogotá, population and housing density are factors associated with a higher number of infections (Prieto et al., 2021; Rizky et al., 2021). In Bogotá, the spread of infections developed from the north to the centre and west of the city, highlighting the latter as the districts with the highest number of infections which were areas with predominantly low-income according to Prieto et al., (2021). These were vulnerable areas in demographic and socioeconomic terms. As for the propagation observed in Jakarta, there is a spatial pattern characterized by a greater number of infections in the western sector of the city, and then moving towards the central and eastern zone (Nur et al., 2020). For its part, in Santiago a greater number of infections is observed in the northeast sector of the city, an area characterized by higher incomes and educated inhabitants, as well as better access to equipment, infrastructure and urban services (Bilal et al., 2021; Mena et al., 2021). The pandemic then spread to the southern and western periphery of the city, areas configured by districts with a high population, presence of social housing and deficiencies in access to transport, green areas and urban facilities (Valenzuela-Levi et al., 2021). Finally, in the case of Singapore, the presence of dormitories is seen as an urban factor in the spread of the virus within the city (von Siedlellin et al., 2021), as seen in the recent spread of other viruses in the city (Seidahmed et al., 2018).

A complementary aspect to what has been raised is that the beginning of the contagions in high-income areas in Bogotá and Santiago, is linked to the fact that the inhabitants of this area enjoy many more opportunities to travel abroad, which is how COVID first arrived in these countries. In the case of Jakarta, the city’s airport is close to those areas where the first advance of the virus was recorded. As a result, people who arrived from other parts of the world stayed near the airport and the virus spread in that area of the city. This is linked to the global character of cities and the global connection that exists today (Sassen, 1991; Prieto et al., 2021).

4.5. Governance

Inhabitants from all four cities were constantly looking to their government for information on the severity and spread of the disease. Residents relied on what they were told to make informed decisions and how to act. Understanding how residents responded to their government actions is crucial for forecasting how people may react in future (health) crises. It also exposes the interactions between local authorities and constituents in difficult times.

Our qualitative analysis produced several findings. Santiago reported the highest testing rate with 171 PCR tests per 1,000 people. Unlike many other countries, Chile set up a remarkable and thorough government policies to the public through traditional (and social) media are remarkable. Considering that it is a common belief that lack of transparency did not play a substantive role in residents’ reaction to government policy. Hence, it is not clear to what extent changes in activity patterns of residents are due to imposition of government policies or other reasons, e.g., international media.

In Bogotá (Colombia) and Santiago (Chile) there were by the time of this study five and three different vaccines, respectively, authorized for battling COVID-19. In both Southeast Asian cities there are only two. Moderna’s vaccines, from an American biotechnology company, were...
only available in Singapore and Bogotá. CoronaVac, which was found in phase 1 and 2 trials to be safe, has been approved for emergency administration in Bogotá, Jakarta, and Santiago. These vaccines were approved before the authorization from the World Health Organization, which came on June 1st, 2021. Bogotá created specific web pages for the vaccination program, which was implemented in its capital city. Jakarta and Santiago, respectively, also created their own specific web pages for the vaccination program. These vaccines were administered in different phases, with Bogotá administering the first doses in December 2020, Jakarta in January 2021, and Santiago in February 2021. The effectiveness of the vaccines was 91.3% in Bogotá, 86.9% in Jakarta, and 91.9% in Santiago.

5. Concluding remarks
5.1. Study limitations

This study has special emphasis on comparative analysis which resulted useful for identifying cross-case mobility differences when combined with effective visualizations and simple statistical tests. Nonetheless, researchers should consider whether the framework is sufficient to capture all the possible multiple relationships between cities. For instance, in terms of our mobility indicators, there are some limitations that must be acknowledged. Data from Google Mobility Reports may not be sufficient to understand all spatial-temporal heterogeneity of urban mobility as the baseline level is interpreted from a value calculated within a 5-week period from January-February 2020. Hence, calculated values are not amenable to policy development as such indicators may be useful for inference, and perhaps short-term forecasting, but not for applied policy analysis. In addition, the nature of the data collected does not allow the estimation of more sophisticated statistical models. As data was collected in different manners in each country of study, the only level of aggregation possible with sufficient and comparable details between the study units was the city-whole level. Thus, as the evolution of the pandemic must be considered as a panel of observations, all urban and sociodemographic characteristic would be perfectly correlated with any constant effect from each city studied. In the absence of such needed variability, the model becomes fruitless. To overcome these challenges, long-term comparative analysis could perhaps be better captured by taking a more granular approach and analysing the evolution of the disease between different districts from different countries, micro data related to public transport infrastructure (such as bike lanes and parking areas) or restrictions to vehicles in highly regulated areas during the lockdown periods (Combs and Pardo, 2021; Jiang et al., 2021).

5.2. Theoretical contributions

We show how structure and morphology of the analysed cities seem to lead to a greater degree of contagion during the COVID-19 pandemic. Even though some of the findings yielded foreseeable results such as the correlation between spatial inequality and territorial segregation in cities and its association with the evolution of contagions over time, as the case of Jakarta shows, such connection cannot necessarily be taken for granted. In the chosen approach, however, we acknowledge limitations to this study.

A collaboration-based approach using a varied number of methodologies, has resulted in a promising source of reliable data in a context in which continued disruption hinders traditional forms of data collection. Yet, as a transnational endeavour, and as in every relationship, collaboration between authors located in different continents and time zones can be tricky, sometimes begetting discrepancies in the data collection and in the results obtained. Overcoming cultural differences as well as practical difficulties, our paper aims to provide not only a timely overview of the pandemic in two antipodal regions, but also for applied policy analysis. In addition, the nature of the data collected does not allow the estimation of more sophisticated statistical models. As data was collected in different manners in each country of study, the only level of aggregation possible with sufficient and comparable details between the study units was the city-whole level. Thus, as the evolution of the pandemic must be considered as a panel of observations, all urban and sociodemographic characteristic would be perfectly correlated with any constant effect from each city studied. In the absence of such needed variability, the model becomes fruitless. To overcome these challenges, long-term comparative analysis could perhaps be better captured by taking a more granular approach and analysing the evolution of the disease between different districts from different countries, micro data related to public transport infrastructure (such as bike lanes and parking areas) or restrictions to vehicles in highly regulated areas during the lockdown periods (Combs and Pardo, 2021; Jiang et al., 2021).

Note: Bold values denote statistical significance at the $p \leq 0.1$ level.
5.3. Managerial contributions

The pandemic exposed numerous problems and deficiencies of urban planning systems in cities all around the world. More specifically, the dislocation between land uses and public transport systems. Thus, based on the cases analyzed we propose three recommendations relevant to decision-making processes as well as to policies designed by governments in the context of the COVID-19 pandemic, particularly in terms of mobility and connectivity.

Firstly, we argue that before making any decision governments need to have a clear territorial view of their cities. Throughout the pandemic, although most of the measures implemented were health-related, they did not take into consideration the effect of urban function over peoples’ behaviours and the spread of vector-borne diseases. Such territorial view would entail changing the geographical scale of cities from metropolitan to neighbourhood level. This will allow governments to focus interventions while considering the territorial heterogeneity and how it is expressed in terms of human mobility, spatial practices, occupation and use of public space, for instance, squares, green areas, and businesses. Ultimately, by proposing a change in the geographical scale from metropolitan to local-neighbourhood level, we will be able to better understand mobility-related behaviours and spatial patterns of inhabitants. This would translate into more efficient policies aimed at restricting or promoting mobility to prevent the spread of infectious diseases.

Second, in the cities analyzed, the poorest outskirts tend to concentrate the bulk of infections in the case of Bogotá, Santiago, and Jakarta, while Singapore presents an interesting parallel with the dormitories of foreign workers. These higher risk areas often lack infrastructure and public Internet access. With the exception of Singapore, the urban poor were among those who suffered the most from the lockdowns. This is primarily due to their inability to work from home, the nature of their unskilled blue-collar jobs, or their lack of access to technology. To reverse inequality and reduce the spread of current or future pandemics, governments on both sides of the Pacific Ocean must begin to focus on critical spots or groups, especially those deprived of technology and with low coverage and frequency of public transportation. Comprehensive interventions combining public transportation management, smart infrastructure, data-driven surveillance, and targeted service delivery with improvements in environmental design are critical.

Thirdly, we contend that, as a consequence of mobility restrictions regarding the use of public transportation, transport alternatives arise that not only give users security to commute to their jobs or other destinations, but that are also sustainable alternatives for the studied cities. In particular, the implementation of road infrastructure such as bike lanes would allow addressing both aspects and be a reliable option for people in a context marked by the pandemic. Other mobility options are the installation of shared bicycle stations, which would allow people to commute, and thus reduce congestion in public transport, and exposure to virus contagion. These are policies that we believe should be designed considering the two previous considerations, that is, visualizing the punctual, by proposing the context of the different areas of the cities, as well as the flows of origin-destination of people to commute to their jobs. It is also necessary to understand that cities do not function internally as immobile units, but rather have multiple dynamics of complex flows between different areas.

In this sense, and considering the above, we propose that the comparative study of urban areas in Southeast Asia and Latin America, as we have tried to demonstrate, could offer numerous possibilities and perspectives with which to engage in search of building healthier and more sustainable cities. We aim to start a conversation about two regions that share a perhaps still unnoticed proximity and to continue that conversation well beyond the context of the current pandemic.

Conclusion

In many ways COVID-19 has proven to be a devastating force that almost overnight and globally, pushed whole countries to the limit. In this context of unprecedented and ever-changing dimensions, cities have become natural stages upon which governments have scrambled daily to reimagine and permanently reengineer normalcy, or perhaps at least its closest proxy. Consequently, cities have become showcases of astonishing success, unamazed failure or the periodic overlapping of both, informed by different levels of government competence, erratic behaviour of a treacherous virus, or simply the citizens’ fatigue that result in resignation and apathy in the face of the pandemic. This paper, in effect, is aimed at exploring, measuring, and comparing the reactions towards the COVID-19 pandemic of four different city governments on the two sides of the Pacific Ocean.

Despite the cities’ similarities in urban contexts, e.g., fast transformation and accelerated pace of urbanization, this paper seeks to fill a gap that is still deeply overlooked by research comparing cities in Southeast Asia and Latin America. Focusing on the cases of Singapore, Jakarta, Santiago, and Bogota our paper sought to measure and compare the efficacy of city governments from the point of view of mobility and governance, and the response of city governments in terms of control and safety measures aimed at restricting mobility, and their ability to disseminate data and information of risk with the arrival of the virus. Likewise, the paper emphasizes the challenges of doing comparative urban research theoretically, methodologically, and practically and in the process highlights interesting nuggets of information about the management of COVID-19. The paper sheds light on the extent to which, unequal urban structure and marked territorial segregation, along with urban factors such as population density, housing concentration and poverty levels are closely related to the number of infections in the cities which we analysed.

The COVID-19 pandemic has brought along an impressive surge of research in different disciplines, including urban studies. This body of literature in effect has contributed to the understanding of the pandemic in cities. Building upon this growing source of knowledge, we locate our contribution to the understanding of the pandemic in urban contexts from two perspectives: theoretical and managerial.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Table A1.
### Table A1

| Socio-economic | Bogota | Jakarta | Santiago | Singapore |
|----------------|--------|---------|----------|-----------|
| Pop. density (inhab/m²) | 0.04 | 0.03 | 0.02 | 0.06 |
| Household crowding (%) | 1.14 | 31.91 | 8.53 | 0.003 |
| Households with poor-quality construction materials (%) | 14.1 | 6.61 | 11 | 0 |
| Average monthly income (USD) | 430 | 283 | 740 | 3.35 |
| Workforce (%) | 79.9 | 68.45 | 62 | 63.68 |
| Life expectancy (years) | 78.93 | 72.82 | 80.97 | 83.55 |
| Average years of schooling | 11.4 | 11.06 | 11.58 | 11.2 |
| Population ages 65 and above (%) | 11 | 4.58 | 16.7 | 0.1 |
| Hectares of green space | 2.826.90 | 3.194.53 | 2.436.86 | 5.700.00 |

### Mobility (Before/During/After lockdown %)

| Mobility | Before | During | After |
|----------|--------|--------|-------|
| Avg. daily metro passengers | 72/18/25 | 84/20/38 | 42/19/4 | 84/20/55 |
| TomTom Traffic Index | 66/58/21 | 53/13/29 | 30/15/36 | 30/13/26 |
| Google visits Retail & recreation | –1/–78/–62 | –19/–55/–31 | –37/–65/–37 | –15/–64/–23 |
| Google visits Grocery & pharmacy | 6/–52/–34 | –5/–24/–10 | –13/–37/–1 | –5/–20/1 |
| Google Parks | 1/–70/–49 | –20/–76/–61 | –32/–59/–29 | –11/–61/20 |
| Google Transit station | 6/–76/–60 | –22/–65/–44 | –33/–63/–33 | –20/–66/32 |
| Google Workplaces | 11/–71/–49 | –13/–46/–30 | –27/–51/–28 | –8/–61/23 |
| Google Residential | –4/37/29 | 8/22/13 | 15/28/1 | 10/39/18 |
| Air quality, PM2.5 (µg/m³) | 67.5/70.3/42.2 | 91.4/112/127 | 62.9/91.5/56 | 43.1/40.3/33.9 |

### Governance (Before/During/After lockdown)

| Governance | Before | During | After |
|------------|--------|--------|-------|
| PCR Test (per 1,000 people) | NA | 0.92/9.2/60.71 | 11.82/171.5/143.5 |
| Mandatory quarantine days | NA | 14 days | 14 days |
| Authorized vaccines | Moderna. | -AstraZeneca. | -Pfizer-BioNtech: |
| | -Pfizer-BioNtech: | -CoronaVac | -Pfizer-BioNtech: |
| | -AstraZeneca. | -CoronaVac | -CoronaVac |
| Government websites providing information on COVID-19 | 3 | 76 | 384 (as per 14-Apr-21) |
| Government press conferences | daily | 682 (as per 06-Apr-21) | 384 (as per 14-Apr-21) |
| Number Tax breaks for SME businesses | 1 | 5 | 985 (as per 07-Apr-21) |
| Number SME loans | US 60 million | US 22.6 billion | US 11.750 million |
| Re-training courses for jobseekers | NA | 4719 | US 5.7 billion |

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