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Impact of the Covid-19 Pandemic on Traffic Congestion in Latin American Cities: An Updated Five-Month Study

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Abstract. This study analyzes the impact of the COVID-19 pandemic on traffic congestion in 15 metropolitan areas of 13 Latin American countries. The database of the Traffic Congestion Intensity (TCI) of the IDB Invest Dashboard is used, it was developed from the alliance between the IDB and Waze and it is correlated with the contagions of the population published by Johns Hopkins Hospital University, for the period from March 9 to July 31, 2020, approximately five (5) months. For the analysis, the areas have been categorized into four (4) clusters, based on the Coefficient of Variation and the TCI/ WHO ratio. For each cluster, the graphs of the variation of the ΔTCI, the contagion cases, and the mobility recovery rate are analyzed. Among the conclusions include that the decrease in the number of infections and the flexibility of social distancing measures can be related to a recovery from congestion and that this can be measured as a function to the rate of recovery of mobility. In addition, the pandemic has revealed less collective and more agile forms of mobility, being this an important opportunity for the region to develop new forms of transport.

Keywords: Traffic congestion · COVID-19 infections · IDB Invest Dashboard · Intensity of traffic congestion · Mobility recovery rate

1 Introduction

The global pandemic due to SARS-CoV-2 or COVID-19 has been public since its appearance in Wuhan, China, in 2019 [1]. Latin America comes to suffer it later, compared to other regions such as Asia and Europe. The first case of contagion officially detected in the region was on February 26, 2020 in Brazil [2] and the first death, announced in Argentina, the following March 7 [3]. This situation has led to the implementation of sanitary measures to try to understand and stop its spread, according to sociodemographic characteristics, mobility and reports on the number of infections and deaths by country and region of the world [4]. Among the sanitary measures are social distancing based on measures such as quarantine and mandatory, total or partial

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confinement. These measures have been heterogeneous among the countries of the region [5] and have directly impacted the mobility of people, among other effects [6–9].

The direct measures that affect mobility are the closure of regional and international borders, suspension or restrictions on the use of urban transport systems, reduction of their levels of occupation, enabling of bicycle lanes and location of medical equipment in transport stations for monitor the temperature of the users or request their identification to guarantee traceability in case of contagion, among others [7, 8, 10–12].

Currently, the conception of mobility goes beyond just the transport of people and goods, being the reflection of a social expression by interrelating in different ways, giving rise to patterns of behavior due to different social experiences, to guarantee communication to different distances, and influencing the regional and world economy [13]. This is in a constant process of change, being a basic need for people in the world. It is part of urban life and an important cultural component and of political, economic and sociocultural development, being essential for its analysis to consider the phenomenon of traffic congestion [14].

Latin America is a flourishing region, whose urban growth has accelerated dramatically in recent decades in an uncontrolled manner [15]. According to [16], it is the second region in the world with the highest urban growth and, with this, its service needs, including mobility and transportation. Traffic congestion problems are evident in the region [17] and, especially, in cities such as Bogotá [18], Cali [19], Mexico City [20], Santiago de Chile [15] and Buenos Aires [21], among others. Accelerating the need for higher levels of urban infrastructure, transportation and investment modalities, representing in expenses up to 3.5% of the region's GDP [13] and, for families, one significant cost to achieve mobilization [22].

Mostly, traffic congestion is an incident problem in capital cities, where its root is due to a complex context, in which political, economic, social, cultural and historical heritage variables are articulated [19]. In this framework, Table 1 shows the number of hours that a driver remains detained during the year due to congestion and the average speed of advance of vehicles in some of the cities of Brazil, Colombia, Ecuador and Mexico during 2019, according to the INRIX Global Traffic Scorecard [23]. In this ranking, 975 cities and 43 countries in the world regions are analyzed and positioned, based on traffic congestion.

Table 1. Congestion time and average vehicle speed for 2019 [23]

Country	City	Number of peak congestion hours	Variation of the average congestion rate with respect to the previous year (%)	Average vehicle speed (mph)
Brasil	Rio de Janeiro	190	−5	11
	Sao Paulo	152	+5	13
Colombia	Bogotá	191	+3	9
	Cali	94	-8	12
Ecuador	Quito	144	0	10
	Guayaquil	130	+4	13
México	Mexico City	158	+2	12
	Guadalajara	85	−10	13

Among other variables, congestion depends on the motorization of travel in cities, where Latin America is one of the highest in the world, along with Asia and the Middle East [24]. The number of vehicles per area (km^2) is higher in Costa Rica (21), Mexico (19) and Guatemala (17) than in European countries. This motorization is reflected in the modal share of travel in the city and in the performance of public transport. This has brought problems and impacts to the accessibility of the population to jobs and education, public health and also, to recreational and cultural activities, in addition the consumption of fuel and other resources.

Currently, as a result of the global pandemic COVID-19, congestion levels have been reduced in Latin America [4, 5]. This decrease has been significant in the first days of the implementation of various social distancing measures. Which indicates that this distancing can be analyzed through mobility patterns. Platforms of the Inter-american Development Bank (IDB) [25], Moovit [26] and Google [27], among others, have published their databases and comparisons with months prior to the pandemic, to be used for the different studies on COVID-19.

The IDB has published the IDB Invest Dashboard [25] which allows monitoring the distancing measures in the region based on its mobility, in real time, with the purpose of tracking the variables so that they serve as input for the public policy-making in the countries. The traffic data published in this Dashboard [25] comes from the alliance between the IDB and Waze [28], with these the Traffic Congestion Intensity indicator (TCI) can be estimated. According to this Index, in the first weeks of the implementation of the distancing measures, congestion in 69 metropolitan areas in Latin America fell significantly. The most extreme case being the city of Lima [29] where a decrease of up to 88% of the TCI is registered.

The purpose of this article is to analyze the TCI of 15 Latin American areas belonging to 13 countries, for the period from March 9 to July 31, 2020, approximately five (5) months. In addition to the data published in the IDB Invest Dashboard [25], the information from Johns Hopkins Hospital University [30], has been used for the COVID19 number of infections. The 15 metropolitan areas have been grouped into four (4) clusters, to serve for the analysis. As shown in the methodology, descriptive statistical measures were estimated for each area from the graphs, based on observing the recovery of traffic congestion, once the contagions decrease. From this analysis, the mobility recovery rate (MRR) is defined, which in most cases is positive and distinctive of the analyzed area. For each case, the dispersion and correlation of the data is estimated for the period of increase of the ΔTCI, after the maximum decrease.

2 Methodology

The data used in this article are obtained from the IDB Invest Dashboard [25], according to the Methodological Note [2], from the agreement of this institution with Waze [28]. This data comes from the information of the mobile phones of Waze users [28], which is aggregated and geocoded in real time every two (2) minutes. The Dashboard [25] uses as the reference or comparison period the week of March 1 to 7, 2020, because traffic patterns were not affected by regional holidays and there were still very few reported cases of contagion in the region. Additionally, governments had not yet issued restrictions or recommendations for social distancing.

It is difficult to compare different cities, with different administrative, legal and historical limits [2, 30] and that do not necessarily reflect their functional and economic reach. In this sense, using IDB's methodology to create urban centers as adjacent grid groups (with more than 1,500 inhabitants/ grid and more than 100,000 inhabitants), the IDB Invest Dashboard [25] limits its publication to urban centers with more 750,000 inhabitants. That is, it restricts the analysis to centers with sufficient activity and historical information from Waze [28], remaining in only 64 metropolitan areas in 19 countries. Using the TCI as indicator for the analysis.

According to [2], the TCI is the sum of the total times and lengths of congestion for periods of 24 h compared to those carried out on the days of March 1 to 7, 2020. With this, a ΔTCI is estimated, which It allows the percentage comparison between the same days of the week, called the ratio-20.

In [25] the information of 64 metropolitan areas is published, however for the present study are considered the cities of Buenos Aires (AR-BA), Santa Cruz de la Sierra (BO-SC), Brasilia (BR-BR), Sao Paulo (BR-SP), Rio de Janeiro (BR-RJ), Santiago de Chile (CL-ST), Bogotá (CO-BO), San José (CR-SJ), Quito (EC-QU), San Salvador (SV-SS), Tegucigalpa (HN-TE), Guatemala City (GT-GT), Mexico City (MX-MX), Panama City (PA-PA) and Lima (PE-LI). The analysis period comprises from March 9 to July 31 of this year, approximately five (5) months. Only for Bogotá, Colombia, the start date is taken from March 9, since the data from the IDB Invest Dashboard [25] started from that day. This country announces the start of its closure on March 2 [29].

The areas were grouped into four (4) clusters, based on the Coefficient of Variation (CV) (which is an indicator developed by the IDB) and the TCI/ WHO ratio, published in [2] as a methodological guide. For each cluster, the ΔTCI variation graphs are analyzed, as a function of time and, in turn, of the daily cases of contagions detected for the same day. The contagion data is taken directly from those published by the Center for Systems Engineering and Sciences (CSSE) of the Johns Hopkins Hospital University (JHU) [31].

For each area, graphic analyzes were carried out and descriptive statistical measures were estimated, based on observing the recovery of traffic congestion, once contagions decrease. These graphs show the lowest point of the ΔTCI and, from this moment, the recovery of traffic congestion in the area, as a line product of the linear regression. With these, the MRR is estimated as the slope of this line, which in most cases is positive and distinctive of the analyzed area. For each case, the dispersion and correlation of the data is estimated for the period of increase of the ΔTCI, after the maximum decrease.

3 Results and Their Analysis

Figure 1 shows the conformation of the clusters of the 15 cities under study, according to the Coefficient of Variation (CV) and the TCI/ WHO ratio, published in [2]. Additionally, Table 2 shows the description of each of these clusters. Next, the graphs of TCI [25] and daily contagions [30]. Are shown for each group of clusters. Subsequently, the cluster analysis shows the general statistical analysis of the areas in summarized in Table 3.

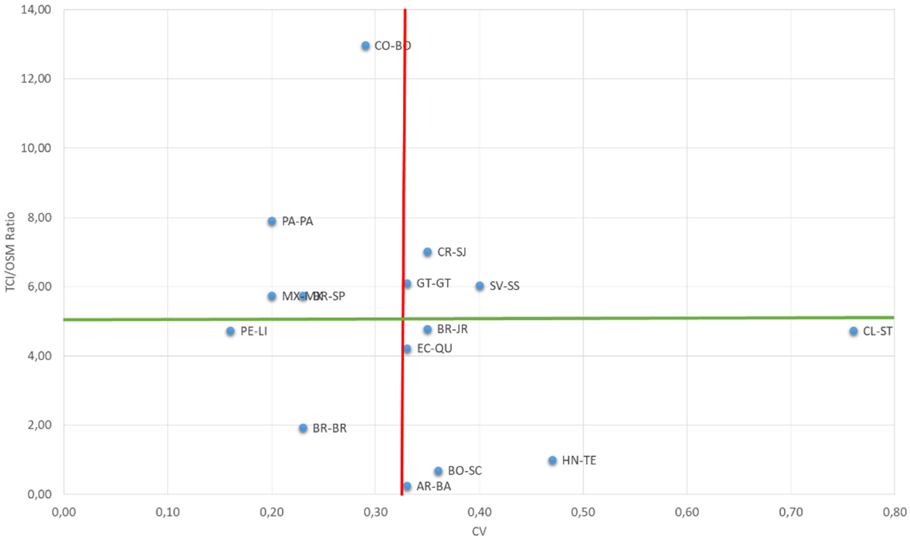

Fig. 1. Distribution of the clusters of the cities (CV, Coefficient of Variation; TCI/WHO, Traffic Congestion Intensity indicator)

Table 2. Definition of the clusters

Group	Definition (1)	Number of cities	Percentage (%)	Member Cities
A	0,33 < CV TCI/WHO < 4,93	2	13,3	Brasilia, Lima
B	0,33 < CV TCI/WHO ≥ 4,93	4	26,6	Bogotá, Mexico City, Panamá City, Sao Paulo
C	CV ≥ 0,33 TCI/WHO < 4,93	6	40,0	Buenos Aires, Quito, Santa Cruz de la Sierra, Tegucigalpa, Rio de Janeiro, Santiago de Chile
D	CV ≥ 0,33 TCI/WHO ≥ 4,93	3	20,0	Guatemala City, San José, San Salvador

(1) Definition: CV, Coefficient of Variation; TCI/WHO, Traffic Congestion Intensity indicator

3.1 Cluster A

Cluster A is made up of the cities of Brasilia and Lima. Figures 2 and 3 show their graphs of ΔTCI and number of infections for the same day, as expressed in the methodology, respectively. In these figures, it is observed that as the number of contagion decreases, there is a relaxation from the point of view that there is a recovery of the TCI. As discussed in the methodology, the MRR for both cities has a positive slope of 30.9 and 44.94%, with a dispersion of 0.1661 and 0.7261, respectively.

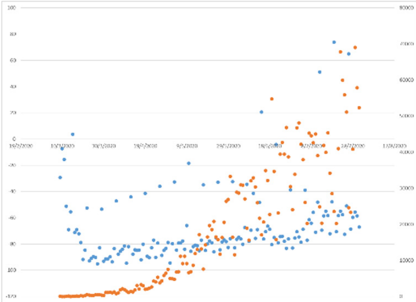

Fig. 2. Recovery of Traffic Congestion (Axis Y1, blue) for Brasilia and COVID19 Infections (Axis Y2, red) (Color figure online)

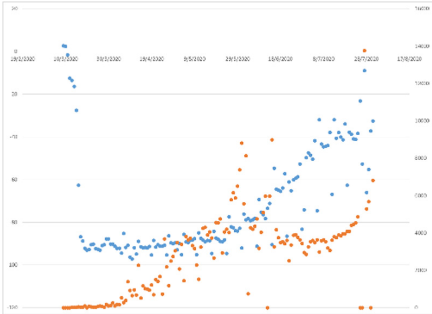

Fig. 3. Recovery of Traffic Congestion (Axis Y1, blue) for Lima and COVID19 Infections (Axis Y2, red) (Color figure online)

3.2 Cluster B

Cluster B is made up of the cities of Bogotá, Mexico City, Panama City and Sao Paulo. Figures 4, 5, 6 and 7 show their graphs of ΔTCI and number of infections for the same day, as expressed in the methodology, respectively. During 2019, Bogotá has been ranked number 1 among the cities with the highest traffic congestion, thanks to its high levels of motorization and other variables. Additionally, Mexico City and Sao Paulo are within the top ten (10). In this sense, this grouping is to be expected. The MRR of the cities is 40; 43.89; 23.2; 54.57%, respectively, with dispersions above 0.5455. This shows that the recovery from congestion is one of the fastest in the region.

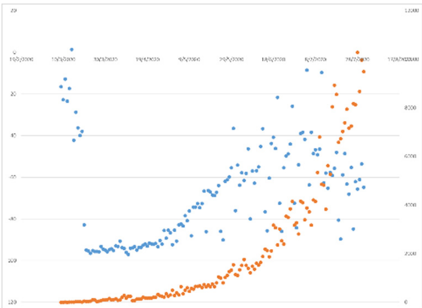

Fig. 4. Recovery of Bogota Traffic Congestion (Axis Y1, blue) and COVID19 Infections (Axis Y2, red) (Colo figure online)

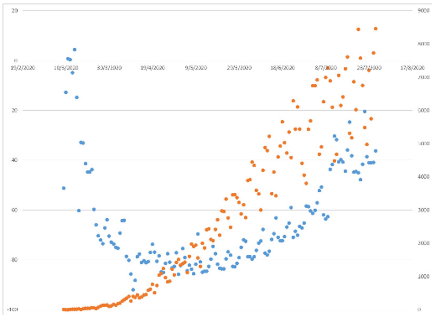

Fig. 5. Recovery of Mexico City Traffic Congestion (Axis Y1, blue) and COVID19 infections (Axis Y2, red) (Color figure online)

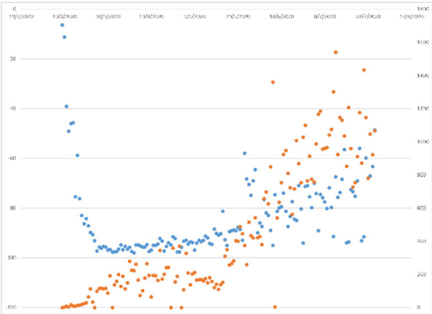

Fig. 6. Recovery of Panama City Traffic Congestion (Axis Y1, blue) and COVID19 Infections (Axis Y2, red) (Color figure online)

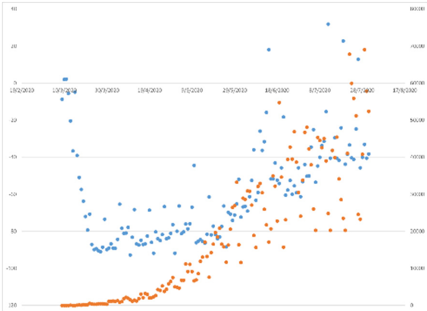

Fig. 7. Recovery of Sao Paulo Traffic Congestion (Axis Y1, blue) and COVID19 Infections (Axis Y2, red) (Color figure online)

3.3 Cluster C

Cluster C is made up of the cities of Buenos Aires, Quito, Santa Cruz de la Sierra, Tegucigalpa, Rio de Janeiro and Santiago de Chile. Figures 8, 9, 10, 11, 12 and 13 show their graphs of ΔTCI and number of infections for the same day, as expressed in the methodology, respectively. In this conglomerate, unlike the previous ones, it is observed that the MRR is 16.7; 29.9; 11.6; 10.4; 51.1 and 5.4%, respectively, with dispersions ranging from 0.013 to 0.8217. Of this group, Rio de Janiero stands out, for having the highest MRR in the group, comparable to conglomerate B, and Santiago de Chile. The latter, unlike all the others, stands out by a recovery in the number of infections from the week XX and in this sense, a correlation of its data close to zero (0.013).

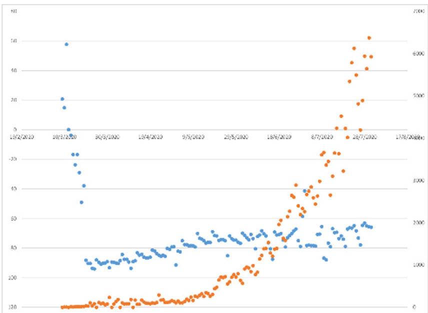

Fig. 8. Recovery of Buenos Aires Traffic Congestion (Axis Y1, blue) and COVID19 Infections (Axis Y2, red) (Color figure online)

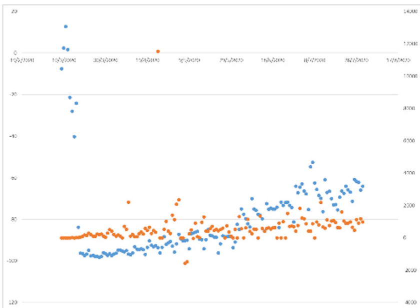

Fig. 9. Recovery of Quito Traffic Congestion (Axis Y1, blue) and COVID19 Infections (Axis Y2, red) (Color figure online)

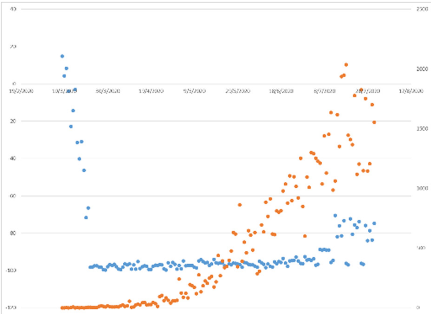

Fig. 10. Recovery of Santa Cruz de la Sierra Traffic Congestion (Axis Y1, blue) and COVID19 Infections (Axis Y2, red) (Color figure online)

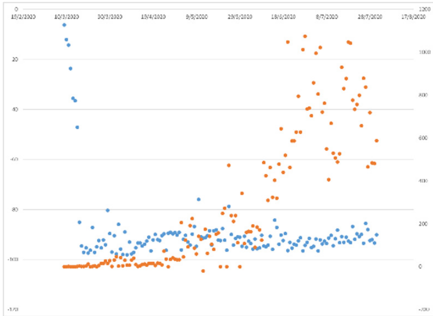

Fig. 11. Recovery of Tegucigalpa Traffic Congestion (Axis Y1, blue) and COVID19 Infections (Axis Y2, red) (Color figure online)

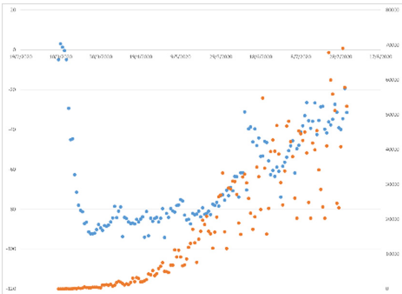

Fig. 12. Recovery of Rio de Janeiro Traffic Congestion (Axis Y1, blue) and COVID19 Infections (Axis Y2, red) (Color figure online)

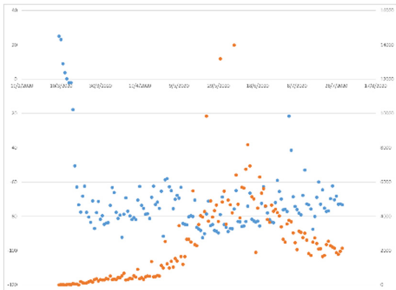

Fig. 13. Recovery of Santiago de Chile Traffic Congestion (Axis Y1, blue) and COVID19 Infections (Axis Y2, red) (Color figure online)

3.4 Cluster D

El Cluster D is made up of the cities of Guatemala City, San José and San Salvador. Figures 14, 15 and 16 show their graphs of ΔTCI and number of infections for the same day, as expressed in the methodology, respectively. In this group, it is observed that the measures implemented for social distancing were aimed at restricting the use of private vehicles or public transport. Their MRR is 2.12; 14.6 and 28.87%, respectively, with dispersions from 0.0017 to 0.6413. The highest dispersion is for Guatemala City and the lowest for San Salvador.

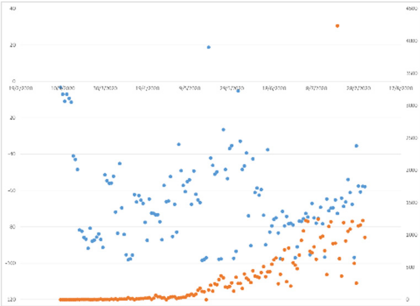

Fig. 14. Recovery of City of Guatemala Traffic Congestion (Axis Y1, blue) and COVID19 Infections (Axis Y2, red) (Color figure online)

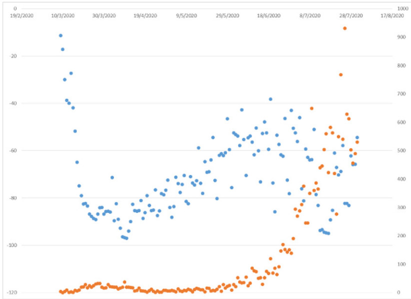

Fig. 15. Recovery of San Jose Traffic Congestion (Axis Y1, blue) and COVID19 Infections (Axis Y2, red) (Color figure online)

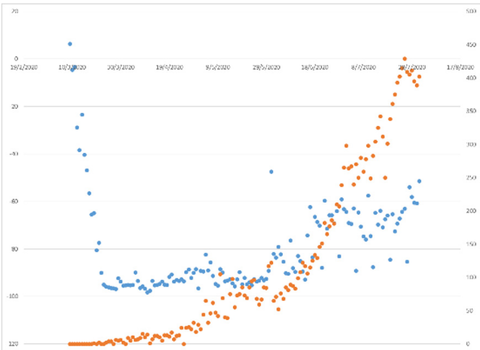

Fig. 16. Recovery of San Salvador Traffic Congestion (Axis Y1, blue) and COVID19 Infections (Axis Y2, red) (Color figure online)

Table 3. Statistical data per area

Country	Argentina	Bolivia	Bazil	Brazil	Brazil	Chile	Colombia	Costa Rica
City	Buenos Aires	Santa Cruz de la Sierra	Brasilia	Rio de Janeiro	Sao Paulo	Santiago	Bogotá	San José
Average Variation in Congestion	-72,41	-87,93	-66,79	-64,58	-59,02	-70,93	-68,04	-70,49
Maximum value	57,64	14,75	73,93	3,05	31,93	25,11	1,38	-11,28
Minimum value	-94,08	-99,74	-95,04	-94,22	-92,74	-92,52	-97,00	-96,99
Standard deviation	21,93	22,74	28,26	23,80	26,99	21,14	23,58	16,94
Median	-76,10	-96,23	-76,14	-73,90	-65,30	-75,81	-68,44	-73,65
Country	Ecuador	El Salvador	Guatemala	Honduras	Mexico	Panamá	Perú	
City	Quito	San Salvador	Guatemala City	Tegucigalpa	Mexico City	Panamá City	Lima	
Average Variation in Congestion	-79,33	-79,50	-66,35	-88,89	-64,54	-83,42	-71,85	
Maximum value	12,75	6,38	18,65	-6,28	4,44	-6,30	2,72	
Minimum value	-98,26	-98,33	-98,38	-98,06	-92,05	-97,97	-97,24	
Standard deviation	20,32	19,41	22,80	15,16	20,42	15,73	24,71	
Median	-86,26	-88,46	-69,23	-92,22	-71,86	-89,17	-84,20	

4 Analysis of Results

In order to understand how the pandemic will affect in the future and, above all, the different changes that may occur from this health emergency, it is necessary to review the transformations that occurred, especially from the 12th and 19th centuries. Fundamentally, these pandemics highlight the health problems associated with overcrowding and industrial development. According to [32] it indicates the rezoning and ordering of the city as a space for “social reproduction” in order to solve the problems derived from unhealthy conditions and overcrowding of people.

If in previous centuries, the bubonic plague in Florence in 1348, which of 1665 in London or the diseases in the city of Seville in 1786, motivated the processes of transformation of the cities. At the beginning of this 21st century, practically the same reasons plague cities globally, with inequality in said social reproduction, health and the environment being a matter of concern for the United Nations System. It is estimated that approximately 828 million people live in slums. In addition, the levels of energy consumption and pollution in urban areas are also considered worrisome, although cities occupy only 3% of the earth’s surface, they represent between 60 and 80% of energy consumption and 75% of carbon emissions [33] and nine (9) out of ten (10) people suffer from health problems derived from poor air quality and 7 million people die each year from respiratory diseases of contaminated air particles [34].

The main recommendations of the WHO for the transformation of transport in cities establish lines of concrete actions for its future in cities:

> “Adoption of clean electricity generation methods; prioritization of rapid urban transport, pedestrian and bicycle paths in cities, and interurban freight and passenger transport by rail; use of cleaner heavy duty diesel engine vehicles and low emission vehicles and fuels, especially low sulfur fuels” [34].

An indicator of the change in the behavior model associated with mobility in this period of restrictions is the increase in Internet data traffic BID 2020 [35]. According to an IDB report during the first months of the application of mobility restrictions, the Internet pressure index (KASPR) was affected in some cities up to 40%, as shown in Table 4. Which can be inferred as the reduction of face-to-face activities and its substitution to virtual ways of work and communications. Since the selected cities are the major cities of each country (Table 2), we assume a proportionality between the behavior of the country and the corresponding behavior of its major cities and capitals.

Table 4. Increase in data traffic on the Internet, according to data in [35]

Country	Percentage (%)
Argentina	22 y 25
Brazil	10 y 20
Ecuador	30 (fixed networks) y 8 (mobile networks)
Colombia	40 (fixed networks) y 12 (mobile networks)

Another indicator of behavior changes in the pandemic has been the impact of restrictions, this time on people’s mobility behavior (5). As it can be seen in Table 5, only trips to second homes increased perhaps as a way to flee from areas with more demographic density, and it can be noted the decrease in movements associated with areas with close personal contact such as leisure and parks.

The pandemic and the different mobility restrictions have shown the need for more agile and less collective forms of transport services. Already in 2014, at the ITS Conference in Helsinki, the concept of MaaS appeared as a set of subscription mobility services [36]. This is defined as the integration of various forms of accessible transport services based on demand for individual mobility. MaaS services provide various menus of transport options, both public, bicycle, taxis, shared or rental car and combinations of both. COVID-19 represents an opportunity for the development of new public-private transport services that would contribute to sustainability, resilience, mitigation of so-called climate change and the health of the population.

For the case of Latin America and the study cities, there are several challenges that must be addressed [37]. To the low quality in time cost of public transport, are added the road insecurity for the most vulnerable (pedestrians), the high level of polluting emissions, its impact on health, as well as the high traffic congestion and a very limited management that prevents the optimization of road infrastructure, as well as the effective prioritization for buses, pedestrians and cyclists. COVID-19 highlights the importance of health when facing these challenges in the future.

Table 5. Mobility in the face of COVID-19 in Latin America [27]

Contry	Stores and Leisure (%)	Supermarkets and Drugstores (%)	Parks (%)	Transport Stations (%)	Work (%)	Second residences (%)
Argentina	-61	-21	**-83**	-54	-28	17
Bolivia	-53	-31	-42	-56	-43	23
Brazil	-40	-2	-39	-38	-22	14
Chile	-66	**-46**	-67	**-66**	-50	28
Colombia	-47	-24	-38	-48	-35	20
Costa Rica	-36	-23	-46	-46	-30	15
Ecuador	-36	-20	-38	-47	-45	23
Guatemala	-48	-32	-40	-63	-42	24
Honduras	-56	-32	-39	-65	-46	20
Mexico	-46	-18	-39	-52	-39	17
Panamá	-60	-36	-50	-61	-53	**30**
Perú	**-67**	-35	-46	-58	**-54**	28
El Salvador	-51	-28	-50	-60	-52	24
Venezuela	46	-27	41	56	-38	19

5 Conclusions

This study begins with the analysis of the impact of the COVID-19 pandemic on traffic congestion in 15 metropolitan areas of 13 Latin American countries. The database of the Intensity of traffic congestion of the IDB Invest Dashboard and the number of infections in the population published by Johns Hopkins Hospital University were used, for the period from March 9 to July 31, 2020, approximately five (5) months. From the categorization of four (4) clusters, the graphs of the variation of the ΔTCI, the cases of contagion and the rate of recovery of mobility are analyzed. It should be noted that the decrease in the number of infections brings flexibility of social distancing measures and the recovery of congestion, which is observed based on the rate of recovery of mobility.

It is observed that the mobility recovery rate for conglomerates A and B is higher than for the rest, coinciding with the areas of the cities with the greatest traffic congestion. In cluster D, this rate is lower, however, they present greater dispersion (seen from the point of view that their correlation is not very significant), coinciding with the areas where the distancing measures were related to restrictions on the use of vehicles individuals or public transport.

Similar to what happens with pandemics of the twelfth and nineteenth centuries, this brings as evidence that social inequality, health and the environment are reasons for concern. Non-negligible effects for citizens, especially in large urban centers, are evident: the rapid recovery of pollution levels and traffic congestion as the economic recovery becomes more pressing

Finally, the COVID-19 pandemic has revealed that less collective and more agile forms of mobility are needed, being an important opportunity for the region to develop new forms of transport in the face of a pandemic which has required people to have physical distance and yet they need to move from one place to another.

However, if the problems associated with the pandemic continue, a review of the World Health Organization recommendations regarding the use of public transport will be necessary. This fact raises a dilemma between maintaining state-of-the-art urban mobility policies (mitigation of climate change), versus public health and the well-being of citizens.

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