

The role of Urban Control and Command Centers in the face of COVID-19: the case of COR in Rio de Janeiro, Brazil

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Abstract— The COVID-19 pandemic imposes a whole new way for cities to deal with crises. More than ever, in order to protect the citizens, cities need to rely on data to address such a public health emergency. In this sense, the Urban Control and Command Centers (CCCs) are an important governance organism to help the monitoring and the management of the complex dynamic of contemporary cities. These centralized and integrated management structures in the form of a governmental agency can aid the decision makers into a more coordinated, systemic, strategic, and data-driven intervention. In Rio de Janeiro's case, the city Urban CCC - called Rio de Janeiro Operations Center (COR in the Portuguese abbreviation) - is mostly designed to monitor the daily routine of the different systems and infrastructures that compose the city's dynamic, to plan and integrate operations for big events like Rio 2016 Olympic Games and to manage emergency situations. With the monitoring center, Rio is able to identify abnormalities and make sure that any interference in the city can be resolved in a timely manner, in order to ensure that the city comes back to normal in the face of a disruption and runs as smoothly as possible. Regarding the context of the pandemic of the COVID-19, Urban CCCs can also be an important tool to manage health emergencies. In this paper, the case of the COR is presented, showing how this Brazilian city is using its Urban CCC to monitor and assist the authorities with real time data intelligence to respond to this unprecedented emergency.

Keywords— *Emergency Management, COVID-19, Urban CCC, Urban Management, Urban Resilience, Pandemic, Health emergencies*

I. INTRODUCTION

The cities around the world deal with different threats and emergencies due to various conditions and sources. Some are more suitable to natural disasters, others deal with economic and natural resources limitations, and so on. As the urbanized areas grow in space and population, the complexity of their territory increases, demanding more infrastructure and basic services to ensure the citizen's well-being and dignity. Unfortunately, due to the social-spatial discrepancies, not everyone has their basic needs attended. With that already multifaceted relationships and tensions in the cities, as well as the already under pressured urban infrastructure and services, it is easier for any disruption to damage the tenue line that holds together a society and compromise its protection and well-being.

The bigger the city becomes, the harder it is to achieve that balance that make one city livable. When a problem occurs or the city faces an emergency situation, such as

major accidents or big storms, the city managers and authorities need to act fast to minimize the impact of those occurrences and become more resilient. Urban Resilience is defined by the Rockefeller Foundation's 100 Resilient Cities Initiative as "the ability of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow, no matter what kind of chronic stress and acute shock they experience" [1].

In that sense, the Urban CCCs play an important role to achieve the urban resilience facing unexpected emergency situations, such as the COVID-19 pandemic that is still out of control worldwide. In Brazil, the cases of Coronavirus reached expressive numbers: over 4.1 million infected and more than 127 thousand deaths according to [2], consulted in September 9, 2020. One of the first Urban CCCs in Brazil is the Rio de Janeiro Operations Center (COR), which is an international reference for this kind of emergency response structure. During the COVID-19 pandemic, COR actively participated and engaged partner agencies in the development of data tools to guide decision making in response to the impacts of this pandemic in the City of Rio de Janeiro. In this paper, it is demonstrated how data is helping city managers to increase urban responsivity and resilience. Also, the context of the COVID-19 pandemic and how it differs from the traditional emergencies is discussed, as well as how the use of data can drive to better decision-making during a health emergency. Finally, the importance of Urban CCCs is evidenced, and the actions and decision-making environment of COR are presented.

II. THE DATA-DRIVEN MANAGEMENT FOR URBAN RESPONSIVITY AND RESILIENCE

Managing a city is already a complicated task when the various urban services and infrastructure are in operation without abnormalities and unexpected events. Managing traffic, public transport, public safety, water supply and sewage, drainage, and public lighting services in addition to solid waste collection requires a very intense routine of control and planning.

These urban services are considered essential for social welfare. In the urban dynamic, any unplanned occurrence can cause delays and interruptions in these services. Depending on factors such as the level of risk, intensity of impacts, and vulnerability of a region, these atypical events can become chaotic or even dangerous for the city and its inhabitants, especially in more sensitive regions.

In emergency situations, the public manager needs to act quickly so that the impact of these events does not cause much damage to the urban dynamic, people's lives and assets. For this, it is essential that the information about an event (or situation) in a given area, infrastructure, or urban service reaches the urban managers as soon as possible. That increases the responsivity of the city. Responsivity is related to actions and responses that combat urban risks and vulnerabilities and also to the time of response to the requests of the population by the public authorities [3].

In this sense, the Urban Command and Control Centers (CCCs) - nomenclature given by Hojda & Martins [4] - have been an important tool for urban management, and they are considered to be one key part of a Smart Cities environment [4]. Also known as operations centers, they gather the preexisting geo-localized data, along with the information collected by the sensors and monitoring cameras scattered throughout the cities in real time. That information is converted to data and is stored, processed, and analyzed through a set of platforms that can generate graphs and maps, as well as indicators of abnormality to assist urban managers. Through the use of visualization tools in a centralized facility, the decision making in the face of disruptive events becomes faster and more reliable. The Urban CCCs can assist the authorities of different levels of public administration in their response to the society, by integrating processes, systems, and teams; by providing a robust infrastructure of data and an environment for stakeholder engagement; as well as by offering means to alert the population, consequently increasing urban resilience.

III. THE CONTEXT OF THE COVID-19 PANDEMIC

According to the World Health Organization (WHO), the SARS-Cov-2 virus, a variant of Coronavirus, causes an infectious disease called COVID-19. That was first noticed in the end of 2019 in the city of Wuhan, China, and due to a considerable rate of transmissibility, it spread rapidly and escalated from an epidemic to a worldwide pandemic in a matter of couple of months. This virus causes serious problems in humans and has a high mortality rate, which increased the concerns among authorities and the general public opinion.

This pandemic also caused various psycho-sociological effects in the society and consequences in many levels of the society structures. In the cities, it caused an **enduring paralysis of urban dynamics**, as the rhythm of the numbers of infected and deaths continues to increase and being out of control in several countries. Not diving into the political issues involved in the combat of the COVID-19 in various spheres of government within the countries, the ways that the cities responded to this threat made a direct impact on its consequences, determining the speed of the transmission, the availability of health assistance and quantity of deaths.

Noticeably, the cities have an important role and the higher responsibility in dealing with the nature of this challenge (pandemic), despite the issue happening at a global scale. That is because the cities are the stage of most of human habitat, interactions, and activities. Also, depending on the urban configuration and how populous and crowded a city is, as well as the behaviors and beliefs of its inhabitants, the epidemics and pandemic can have different outcomes.

In that sense, this pandemic requires the authorities at different levels of public administration to act in the

identification, tracing, containment of proliferation, and protection of the population, especially in urban areas where there are greater concentrations of population and physical interactions. Also, they need to deal with society control and the context of political divergences of the contemporary social media-based society, where the science is being questioned and there is a lot of misinformation and fake-news.

Different from the other types of emergencies, the COVID-19 pandemic evidenced certain characteristics of the health emergencies in the scale of a worldwide pandemic. That kind of emergency does not go through the cycle of urban resilience to disasters, whose complications are punctual and generally temporarily impact local dynamics and urban infrastructure (they have reasonably defined the beginning, middle and end). In the case of the pandemic, there are factors of uncertainty, invisibility of the threat, unpredictability of recovery times and deadlines, population behavior and mistrust in institutions and science. Table 1 contains a comparison between the characteristics of traditional emergencies and COVID-19.

TABLE I. COMPARISON OF THE EMERGENCY CHARACTERISTICS^a

<i>Traditional Emergencies</i>	<i>COVID-19 pandemic</i>
1. Punctual complications	1. Large scale implications
2. Momentaneous impact	2. Lasting impact
3. Evident and undeniable information	3. Uncertainty and misinformation
4. Recovery Timeline reasonably defined	4. Unpredictability of recovery timeline
5. Event is visible	5. Invisibility of the threat
6. Transitory shock and solidarity	6. Population behavior changes
7. Trust in the authorities (mostly)	7. Mistrust in institutions and science

^a Developed by the authors for this paper.

Considering all the specificities of this unusual emergency, the cities need more than ever to rely on data to understand the complex situation and to substantiate their decisions and actions. Also, the multilevel decision-makers within the city need to be "on the same page" while their response needs to be coordinated and integrated.

A. Data for decision-making during a pandemic

Given that data helps to subsidize better decisions, especially in complex situations such as a pandemic, it is important to have a structure that accommodates that level of engagement and supports the volume of data generated and collected from different sources. Besides, the patterns of the urban dynamic during a pandemic change drastically, requiring the authorities to be able to redefine their normality indicators and safety threshold.

The integrated data can be used to improve decision-making towards essential public services, and to develop actions to control the agglomerations of people, as well as keeping the population informed through alerts, via various physical and network media. It is also essential to identify the vulnerable areas and sectors of the society that require more attention. With the integration of the data provided by the health authorities and the data collected around the cities and urban services, as well as gathering the different subject-matter specialists and stakeholders in a single control and command center, the urban managers will be able to formulate emergency action policies. Also, the operations centers can coordinate with the health authorities, traffic controllers and other city agencies, in order to solve logistics

problems related to services that must run continuously, even during a scenario of quarantine, lack of transportation offerings and other abnormalities.

All those particularities of a pandemic highlight the need for a high level of integration between public agencies and teams to manage such a complex scenario. In this sense, Urban CCCs can play the role of an integration hub within major cities and metropolises. In Brazil, a case of success and international reference is the City of Rio de Janeiro's Operations Center.

IV. THE ROLE OF THE RIO DE JANEIRO OPERATIONS CENTER - COR FACING URBAN EMERGENCIES

The Rio de Janeiro Operations Center (COR) is an Urban CCCs that serves as a headquarter for the City Hall's operational teams, since January of 2011. This structure has high-tech systems and concentrates almost 30 working agencies that act synergistically for control and monitoring of the city. The center operates 24/7 with the purpose of anticipating problems and pointing out solutions, as well as simultaneously communicating the main competent bodies for immediate action whenever an abnormality occurs. The alerts generated by the intelligence systems implemented in this structure also serve to support joint decision-making in the face of urban emergencies [5]. Fig. 1 shows the main monitoring room.



Fig. 1. Monitoring Room of COR [6]

A. Characterization of the crises that COR faced

The main fronts of action of COR, which is why the agency was created, are: the integration of operational responses to urban emergencies; the logistic support to the events with medium/high operational impacts in the city; and the management of the city daily routine. Below is a brief overview of the crises that COR has handled since its creation:

- **Crisis and urban emergency:** monitoring of the daily life of the city and its dynamics, as well as occurrences of natural origin such as rains and floods, the flow of traffic that impact urban mobility, and surveillance of urban violence. Fig. 2 illustrates the rainfall-related occurrences panel.
- **Medium/high impact events:** operational planning and execution support to major sport events, such as the 2014 FIFA World Cup and the 2016 Olympic Games; and concerts or outdoor festivities, highlighting the actions during Rock in Rio, Carnival, and the New Year's Eve in Copacabana, for example. Fig. 3 illustrates the size of some of these events.



Fig. 2. Dashboard of the occurrences related to rain [7]



Fig. 3. Mega events in Rio de Janeiro

- **City daily routine:** COR is a very “hands on” CCC, in a way that monitors continuously indicators and operations needed to keep the city urban operations running well. Every time an unexpected occurrence is identified, COR acts to integrate services needed to respond to it, at the same time that alert citizens for the impacts that they may experience due to the identified problem.

The COVID-19 pandemic can be considered a crisis that requires a response operation in the city level, in addition to the response of the other federative entities. However, this crisis is very different from the ones that COR is used to deal with because: it is widespread across the entire city territory; uncertain in terms of time and pattern of contamination (where most cases are asymptomatic); and highly disruptive for the urban dynamics. The pandemic impact multiple aspects of the city (social, environmental, urban services, economic, human activities, and city flux), causing a lasting paralysis of the urban dynamics of the city of Rio de Janeiro, as well as in many others around the world. This scenario can be treated as the longest urban crisis ever managed by COR.

B. Adaptation to the differentiated crisis context

The pandemic is a health emergency, which is another urban emergency where the Urban CCC needs to be prepared to act to promote urban resilience. Given the range and complexity of a pandemic (and the new set of variables involved), it is essential to know how to work with the data. This was the great advantage of COR, which could act fast because it already has technical mastery and a technological structure to deal with data, protocols, and process. This expertise reflected in the rapid adaptation to this context of a differentiated crisis and even with the specificities of the pandemic, and COR managed to pivot the focus of its performance and realign its objectives and actions. Although the physical space of the center was more restricted to employees and other stakeholders, the performance was maintained, and the engagement of partners was strengthened even more.

C. Stakeholder engagement and trust relationship with the population

This closeness among stakeholders in COR was also an important advantage in facing this pandemic. It was mainly due to the lack of widespread experience of public agencies in the face of this unusual situation, which evidenced the need to use the data for planning tactical actions and decision making.

In addition, the channels of communication with the population built over the ten years of operation of COR was fundamental to establishing the relationship of trust, especially in this period where there is a marked mistrust in institutions and science.

COR provides a “news agency” service, which serves as an official source of information about the city’s operations, including informing the population on how to stay safe in the face of the crisis. This communication strengthened the interaction between the government and society [8].

In all communication channels, COR uses the same alert visual identity, using different color scales to indicate the level of disruption of the city and risk to human life. Fig. 4 illustrates the alert banners system according to emergency stage classification. Normality, Mobilization, Attention, Alert and Crisis. Also, COR counts with an alert function in their Twitter account (Fig. 5).



Fig. 4. Alert System system using color scales



Fig. 5. COR's Twitter alert function

All this facilitates the comprehension of the public, even for those individuals with limited education.

V. COR ACTIONS IN RESPONSE TO THE PANDEMIC

This section was based on the report “COVID-19: Actions Taken” [9]. Among the main fronts of COR’s work in the face of the COVID-19 pandemic, the authors highlight the intensification of communication with the population, the management of strategic partnerships, the development (and improvement) of technology and data solutions. In addition, it acted in the strengthening of the integration of operational processes, with the creation of a Crisis Office, creation of control room in the field hospital in the convention center (RioCentro), place where the mayor began to give the orders and where the press conferences were being held from the beginning of the pandemic in Rio. In addition, COR supported the Municipal Health and the Public Order departments in the creation of a new service for citizens to

denounce prohibited people agglomerations, serving as a real time source of information for field teams to disperse the irregular concentrations [9].

Other actions were also put in place, such as the development and adaptation of panels for data visualization that addressed the specificities of this particular crisis, integrating them with the management of the city's operational routine. These panels were designed for a better tactical and strategic view of the data collected during this period. At the same time, COR participated in a benchmarking effort of pandemic responses based on cities in Brazil and across the world, so that response experiences could be shared. Together with the Public Health Secretary, Civil House, and Institute Pereira Passos (IPP), COR also participated in the elaboration of the official COVID-19 dashboard available publicly for citizens, and in the recovery plan for the city, aiming at the gradual return to the routine of the city [9].

A. Communication to the population

The communication with the population is one of COR’s main fronts of action, as it provides alerts to citizens in the face of emergencies, especially in the risk areas or in the locality of an occurrence. COR’s various communication channels are one of the most effective ways to protect the population of the city of Rio de Janeiro, because they allow citizens to prepare in advance or seek shelter in a safe place during an emergency situation.

This communication intensified during the COVID-19 pandemic. Since March 2020, COR kept its communication team working 24/7, with the publication of daily notes and social media posts about the city’s conditions in the face of the measures adopted by the city in combating COVID-19. Besides the work in partnership with the communication team of the mayor’s office with the sharing of institutional videos, COR also maintained its daily schedule of reports, not only about the operating conditions of the city (more related to the traditional routine of the city), but also the changes in the city in the face of the restrictions caused by the pandemic. In addition, COR kept a daily submission of the summary of the day to the news agencies for dissemination in the main channels of the press [9].

Some of COR’s communication numbers [9]:

- **Followers in social media web:** 1.3 million social media profiles
- **Timelines reached per day:** 1.7 million social media profiles
- **Engagement level per day:** about 13,000 interactions
- **COR lives during the pandemic:** more than 140,000 views

Since March, COR has been on a high operational stage, having changed to alert stage almost at the same time that the City Hall declared quarantine mandatory measures.

B. Partnerships

Among the actions that COR coordinated, it was the partnership management with external partners, such as academia and private sector to help combating the COVID in the city [9]. Below are the main ones:

1) *Federal University of Rio de Janeiro (UFRJ) partnership to provide mathematical projections*

COR partnered with the UFRJ Mathematics Institute, which was part of a multidisciplinary group with more than 15 researchers [9]. This group developed mathematical studies on strategic aspects of the evolution of pandemic, with the elaboration of technical notes containing predictive studies, such as:

- Projection of the evolution of confirmed cases per day
- Projection of total confirmed cases
- Projection of the impacts of the quarantine period in reducing the contamination intensity
- Projection of intensive care unit's occupation

2) *Cellphone users' data to understand people's agglomeration behaviour, in partnership with TIM*

TIM is an Italian company that provides cell phone communications in Brazil. During the pandemic, COR established a partnership with TIM to obtain user geo-localized data (anonymized), in order to create the infrastructure for data transfer and technological integration, enabling the COR to receive raw data from TIM [9]. As a result, COR developed a dashboard in which it is possible to observe variations in number of people concentrated in key areas of the city. Fig. 6 shows one of the panels elaborated with data provided by TIM.

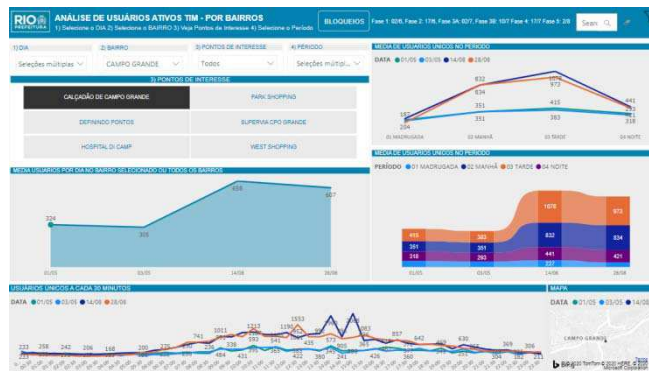


Fig. 6. Monitoring panel of geolocated data from mobile phones (developed with TIM data) [9]

3) *COR and Cyberlabs collaboration to develop the social isolation official index*

Cyberlabs is a Brazilian startup that develops Artificial Intelligence solutions. Before the pandemic, the startup was already running a pilot with COR, applying an AI solution using city cameras images to monitor the quantity of people that access public transportation stations. With the need to monitor social isolation, Cyberlabs and COR quickly adapted the solution, transforming it into the city official social isolation index [9]. As the solution was running before the pandemic, it allowed COR to compare how many people were circulating in the city before and after the quarantine measures announced by the City Hall. This index was broadly communicated to citizens through COR's media channels and also by local news broadcast companies. COR was able, for example, to expose this index using the street's digital clocks (Fig. 7), showing citizens how effective were the quarantine efforts in different regions.

The result of this partnership was a video-analytical algorithm for real-time analysis of the images from the

cameras around the city [9]. The main limitation was the quantity and the quality of the cameras, which reduced the completeness and the effectiveness of this initiative by not covering the entire city territory.



Fig. 7. Press article showing the Street Digital Clocks containing the information about the social isolation index [10].

Fig. 8 and Fig. 9 shows the two dashboards created by Cyberlabs To indicate the agglomeration rate of people and the percentage of social isolation in various areas of Rio de Janeiro.



Fig. 8. Example of periodic report on people agglomeration (prepared by Cyberlabs) [9]



Fig. 9. Percentage of social isolation per monitored area (prepared by Cyberlabs) [9]

4) *VM9 solution to real time monitor city bus fleet*

VM9 is a startup with smart cities solutions expertise and data platform development experience that won the second edition of COR open innovation challenge, in 2019. Originally, the startup's business model was focused on the improvement of the road fleet within the City of Rio de

Janeiro. During the pandemic and under the mentorship of specialists unified in COR, VM9 shifted its focus to attend the new demand of the city and created a platform that generates analyses of the impacts of the COVID-19 crisis on the city's bus system [11]. The aim of that real-time platform was to calculate the percentage of impact on the system, highlighting which lines were in operation and which lines were no longer active due to social isolation. Fig. 10 shows the impact on the number of buses and road transport lines in the city of Rio de Janeiro during the pandemic.



Fig. 10. Impact on the number of buses and road transport lines in the city of Rio de Janeiro during the pandemic (provided by VM9) [12].

With VM9 solutions, COR could expand its capacity to monitor new indicators for the road fleet in real time. These indicators are related to the average speed, the occupancy rate of bus corridors, the frequency and interval of trips, the fulfillment of service quality parameters (according to what was agreed in the concession contracts), among others [11]. Fig. 11 shows a graphic example on the VM9 platform on the impact of COVID-19 on bus services in Rio de Janeiro.



Fig. 11. Detailed monitoring panel of the impact of COVID-19 on bus services in Rio de Janeiro (provided by VM9) [12].

In addition to the visualization panels made available by partners external to COR, the agency has developed and improved a series of dashboards with data from its traditional stakeholders. These stakeholders are part of more than 30 public agencies that influence the decisions of Rio de Janeiro, in the various spheres of public administration [9]. Those dashboards made relevant contributions for the success of COR's and the City Hall's decisions and actions.

C. Dashboards for decision-making during the pandemic

One of the biggest taskforces that COR headed was the development of several dashboards for visualization of COVID-19-related impact data [9]. The following dashboards helped the city stakeholders to make decisions with the aid of consistent, multisectoral and reliable data, increasing the efficacy and speed of the actions in different urban services and in the society.

1) Reports of agglomeration (1746)

The city offers a call center for citizens (1746 or 1-RIO) to receive denouncement, complaints and demand for services. During the pandemic, the same phone number was also used as a channel to receive reports of the agglomeration spots from the population [9].

Fig. 12 and Fig. 13 illustrate two different panels with the results of the population denouncements, georeferenced. The second one has a more focused level of details and are exclusive for the city managers. With this data, COR sends the information to the municipal public order secretariat to act to disperse the non-recommended concentrations of people around the city [9].



Fig. 12. Panel with the reports of agglomeration (Public Panel) [9]

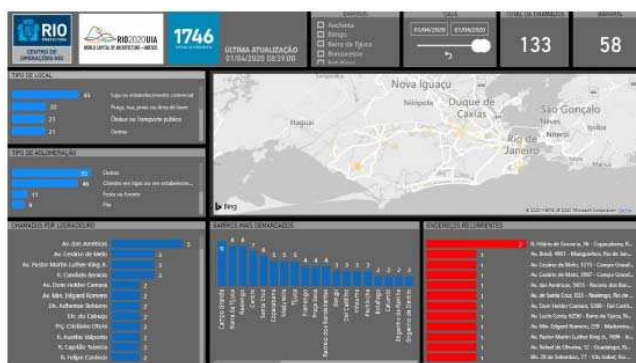


Fig. 13. Panel with the reports of agglomeration (Managers' panel) [9]

2) Regulatory Acts

Another very data panel created by COR, in partnership with the Civil House Secretary team, was the Regulatory Acts dashboard, synchronizing and categorizing regulation determinations from different federative entities that wield an influence on the municipality of Rio de Janeiro. This dashboard helps the authorities from different sectors to follow the most recent rules while they are deciding about their tactical actions [9]. The data is separated by subject (commerce, health, city employees, and citizens). Fig. 14 shows the layout of the panel.



Fig. 14. Panel of regulatory acts [9]

3) Urban Mobility agglomeration monitoring

Urban mobility has always been one of the biggest problems in the city of Rio de Janeiro, but during the pandemic the nature of the mobility problems has changed. Public transport was and is a great means of transmitting the virus and contamination of the population.

In response to that, COR hosted the monitoring of the transport system through the actuation of CIMU (Integrated Center for Urban Mobility, a network that gathers all urban mobility stakeholders in Rio) in the COR control room. They created dashboards reporting the demand for public transport, in view of the restrictions of displacement because of the pandemics, as well as tracked the level of agglomeration into the public transportation [9]. That was the first time that COR and CIMU network managed to integrate raw data from different modes of transportation in the same panel.

Fig. 15 shows the drastic reduction in the demand for all different types of public transportation services. In this panel, in addition to data on transport demand (such as subway, BRT and trains), there is also data about the number of taxi requests and congestion level. This panel relies on data provided by Waze, as well as Moovit and Taxi.Rio, a local taxi driver app [9].

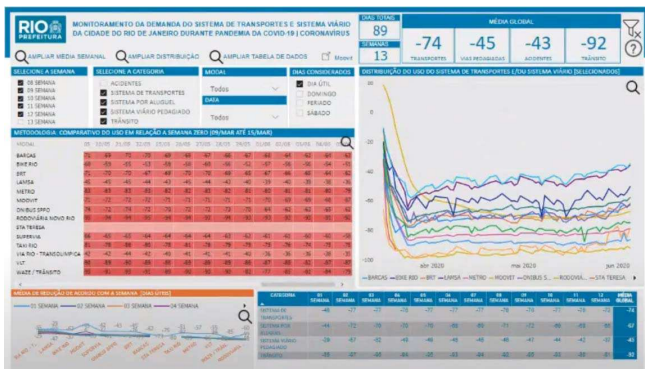


Fig. 15. Panel of Demand Analysis in the Transportation System [9]

Among the main safety measurement actions, the priorities were the mandatory masks, vehicle and public transport stations cleaning protocols, scheduling of working hours, restriction of seat occupancy, vehicle occupancy control, safe routes for bicycles. Fig. 16 Fig. 15 shows the CIMU dashboard demonstrating the “agglomerometer” – how many people are within different modes, hourly – along the day in different systems. The pink line is the limit of the maximum occupancy rate to ensure safety [9].

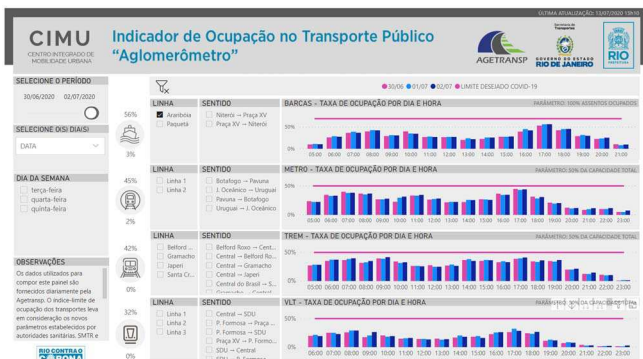


Fig. 16. Panel of Agglomeration indicators in Public Transport, informally called “agglomerometer” [9]

4) Vulnerability Areas

COR also supported the development of the Vulnerability Dashboard, in partnership with IPP and Civil House Secretary teams, with the objective of mapping the areas of the city where there are higher concentrations of citizens that are more vulnerable to COVID-19. The data includes population age, demographic density by housing, among others [9]. This dashboard is not available to the public, because it gathers sensitive data in an effort to show the authorities the areas where they need to act most, helping to prioritize actions. Fig. 17 shows a heat map indicating the areas with more vulnerability.

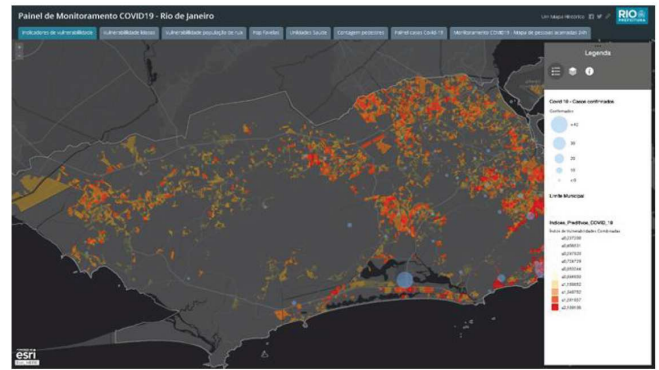


Fig. 17. Heat map of more vulnerable areas for the spread of COVID-19 [9]

This map also highlights some socioeconomic issues being reproduced during the pandemic. The North Zone of Rio de Janeiro is the one with the lowest socioeconomic indicators, and correlating this data with this dashboard, it is evident that the areas with more vulnerability are also the ones with low index of urban services and other social well-being parameters.

5) Monitoring of COVID-19 cases

The COR is tracking the evolution of coronavirus cases in the city of Rio de Janeiro since March of this year, through an open data panel developed in partnership with the Health Secretariat and IPP. The dashboard created identifies the number and location of suspected and confirmed cases, as well as the age average of those infected and the total number of hospitalized in the municipal healthcare system, highlighting the ICU occupancy and the mortality rate, among other information [9]. Fig. 18 shows the most recent numbers of the COVID-19 in the city of Rio de Janeiro. This dashboard helps the authorities of the city in the decision regarding the progressive reopening.

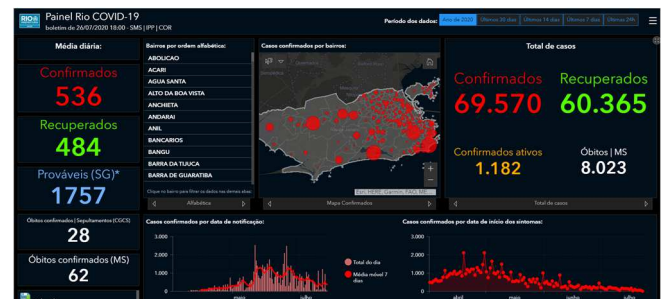


Fig. 18. COVID-19 Case Monitoring Panel [13]

This paper does not aim to analyze any of the data contained in those dashboards, **although** it is clear how much easier it is to generate assumptions based on **the** rapid visualization of the systematized data in the dashboards. This

helps not only the authorities and specialists in each field of urban sciences, but also the citizens and press coverage. When the data is available and organized and the information is presented in a consistent and clear visual representation (such as the alerts provided by the communication channels), it facilitates better understanding.

VI. CONCLUSIONS

It is evident how the Urban CCCs use of smart city technologies can help cities and citizens in times of crisis. This includes public health emergencies such as epidemics and pandemics. By ensuring the functioning of essential urban services, those facilities and technologies can increase Urban Resilience and enhance responsiveness of public agents.

Before the COR existed, the city was not used to working with data. After ten years of implementation, the COR acquired expertise in dealing with urban emergencies, engaging stakeholders and the population, and mostly knowing how to effectively extract sense of data. With the pandemic, due to all the variables it produces, the authorities were forced to work with data. Because of the knowledge COR acquired on using data, the city of Rio de Janeiro was better prepared to deal with this emergency, even with its uncertainty and lack of consolidated past references.

Institutional challenges must be considered in the implementation of Urban CCCs in a city, as well as its particularities, culture, and weather. Also, while dealing with urban emergencies, especially those that are more complex, the ideal response sometimes is unachievable: it is necessary to do the best that they can as fast as possible, and failures and bad decisions can happen still. Also, in order to achieve a level of excellence, the Urban CCCs might have a stronger level of stakeholder engagement to ensure that everyone is in the same page and pace, while coordinating integrated multisectoral actions. It was also observed that COR has moved forward in organizing and visualizing data. The bottleneck though is the origin of the data and its quality and constancy. The process of inserting the data is still analog, and many times unavailable, what does not allow COR to evaluate in depth that kind of emergency.

The tools presented in this article are providing solid contributions for the management of this urban crisis caused by COVID-19. The partnership with UFRJ for mathematics projections gave direct support for decision making within the Public Health department helping, for example, with the building of indicators for the reopening plan. The collaboration with Cyberlabs created the official social isolation index, communicated to citizens by media channels like street digital clocks and local news broadcast companies. The transportation demand panel and VM9 monitoring platform helped city managers to understand population commuting behavior during the pandemics. The transport agglomeration panel influenced decisions, such as defining the opening hours for commercial stores and shopping centers. Besides that, this panel also oriented city hall managers to reorganize their teams along the reopening plan, impacting around 150,000 professionals. The agglomeration report service dashboard provided real time information for the field teams to tactically define field operations to disperse undesirable concentration of people throughout the quarantine and reopening stages.

When evaluating advances in COR action, it is recommended that: 1. the successful experiences are maintained and that the failures in the performance and bottlenecks be used as an example for the improvement and integration of the team of specialists; 2. data analysis and data intelligence methodologies for urban management and planning used in COR need to be consolidated and improved, especially regarding the sources of the data. With that, when facing other emergency situations such as the pandemic, COR can provide an even faster and more effective response to the city of Rio de Janeiro.

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