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A Platform for Citizen Cooperation during the COVID-19 Pandemic in RN, Brazil

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***Abstract*—The coronavirus pandemic challenged smart cities to encourage citizens towards the social distance, as well as to optimize health and policing resources allocation. Mobile apps have played an unprecedented role during this pandemic to enable citizens to participate and interact with social issues while raising concerns about privacy and surveillance. In a partnership of the Natal smart city initiative of the university and the public ministry, we deployed the "Tô de Olho" (TdO) platform for integrating different sectors of society against coronavirus spreading in the state of RN, Brazil. In less than four months, TdO reached more than 20,000 users with several user roles, functionalities and a strictly defined privacy policy. Location data allows TdO to notify users when they have possible suspicious contact with an infected person or have gone through virus hot zones. The platform also helps city health officials to select people for infectious testing, according to user information on symptoms, comorbid diseases, contact with infected people, risk status and QR health code. Our integration with private institutions enables employers to know which employees have tested positive to protect work environments. We discuss the partnerships involved with TdO's deployment and compare our context with related apps around the world, suggesting that public scrutiny, government investments and integration with active applications in the city are essential to achieving massive use. Further, we evaluate the feedback of active users (N = 175), analyzing the positive points and advising improvements for future work on participatory applications during an epidemic.**

***Index Terms*—smart cities, pandemic, citizens, contact tracing, infectious testing.**

I. Introduction

Before the coronavirus pandemic, epidemics have taken place in a much less globalized context in terms of technological ubiquity. The spread of mobile apps was still emerging when H1N1 influenza spread throughout the world in 2009. Nowadays, mobile internet traffic significantly surpassed desktops at the same time that smart cities have been demanded to use ICT infrastructure for improving people's quality of life, for example, through participatory governance [1]. Three foundations for such participatory model are technology, people and institutions [2]. During the COVID-19 pandemic, several challenges emerged to instigate participatory solutions that are driven by these foundations. Thus we claim smart cities to answer: **how technology can enable citizens to collaborate with public agents and, most importantly, institutions to collaborate with citizens during an epidemic?** As an example of early mobile app efforts that appeared on this period, "digital contact tracing" has been implemented using mobile apps in several developed countries to instantly alert users who have had contact with people tested with COVID-19. Studies have suggested that this approach can significantly reduce the virus' spread virus [3].

Further, the coronavirus pandemic challenged smart cities to stimulate social distancing, as well as health and policing resource allocation. Since the economic distress has forced governments to take urgent measures and spend much more than usual, information about social isolation level, virus hot zones, and agglomeration hot spots can be crucial for an integrated decision making during an epidemic. Therefore, citizens cooperation can be vital to enable such an information network, for example with location-based interactions. Although there is an open discussion about privacy and surveillance in centralized systems [4], we will argue that the people's contribution, reporting agglomerations hot spots and temporarily sharing their location data with rigorous ethical compliance, can support better management of the city's resources. On the other hand, data protection guidelines must be strictly defined, followed and monitored by institutions of legal representation of the people, for example by prosecutors. Then, local authorities must put the citizens in the loop, by attending their denunciations and giving back information on infectious risks levels they are exposed to given the location shared. Also, a diverse set of functionalities stimulate different sectors of society towards more engagement.

In this work, we consider fundamental requirements for a smart city to interact with citizens towards social distance measures and better public services allocation during an epidemic. Our solution for these requirements is the **TdO** platform, running in Rio Grande do Norte, a northeastern state of Brazil. The platform consists of a mobile application, a web module and a dashboard that, which in less than four months achieved more than 20,000 users. Citizens, private institutions and public agents have distinct roles in the application, so they can cooperate together with the functionalities available. The platform was developed In a partnership of the Natal smart city initiative of the university and the public ministry, which also collaborated with a clearly and strictly defined data protection policy.

Besides the denunciations and social isolation level monitoring, the platform leverages two other important functionalities. First, we approach digital contact tracing with centralized methodology based on GPS also considering user contact with virus hot zones. Although this approach can lead to a relatively high rate of false positives, we discuss with user feedback that the panic sensation generated by our contact notification may not be too high as it may be expect. Second, the platform enables a selective infectious testing functionality for health authorities to schedule patients based on several metrics, e.g. age, recent contact notification, comorbid diseases (i.e. subadjacent diseases, mainly diabetes, cardiovascular or respiratory). Public health agents can send invitations to the users, that can accept, decline or reschedule the free test. Test results can be immediately processed to inform private institutions whether an employee was positive, if the user agrees. Private institutions can be benefited by isolating workers temporarily and negotiate with the government towards a safe quarantine flexibilization.

Although the requirements for citizen cooperation during the pandemic we list is by no means complete, it can be used as a preliminary guide for evaluation. We discuss user feedback on some of the proposed requirements, aiming to explore the impact of the platform in improving citizen cooperation. We surveyed active users (N = 175) about their opinions on how the TdO has fulfilled its role during the pandemic. We asked about risk levels transparency, panic sensation from contact tracing notification, current limitations of the platform, among others aspects. The survey leveraged material for discussing improvements and for advising future work when implementing citizen cooperation apps during an epidemic.

This paper is organized as follows. In Section II, we describe in which institutional context TdO was developed and what privacy guidelines were established. In Section III, we list requirements to support citizen cooperation during the pandemic. Section IV describes the platform regarding its architecture, user roles and approaches used, detailing the application and particular functionalities. In Section V, we discuss TdO partnerships, comparison with related apps around the world, and discuss user feedback on the main functionalities. Finally, we provide concluding remarks in Section VI.

II. Ethical considerations

The TdO platform was developed within the Natal smart city initiative [5], in partnership between the university and the local public ministry (MPRN), providing services for the citizens of all cities of the Brazilian state of Rio Grande do Norte (RN). One of our primary concerns when developing the platform was not to implement a surveillance instrument for social control neither to reduce individual freedom. Public ministries in Brazil has the responsibility of monitoring and reporting illegal government actions, and are independent institutions that leverage citizens' concerns. Although we collect citizens sensible data, MPRN has established a privacy policy[1] clearly stating that the only institution within the government that will have access to the data is the state health department, which has the same responsibility to protect personal data eventually used.

MPRN explicitly undertakes not to use the data in any new, filed or ongoing legal proceedings, as well as to destroy sensitive data after the end of the pandemic. Neither the government office, nor police, nor private institutions will be able to use data protected by the privacy policy externally. Instead, aggregate information will be available to support immediate decision making and resource allocation.

III. Platform requirements

In the context of a smart city, we envision six main requirements to enable public interactions between citizens, private institutions and public authorities during the pandemic.

1) Public denunciations: citizens must be able to identify and alert local authorities about various problems in the city, for example, places with a high concentration of people. They will wait for their complaints to be answered, so the public authorities must receive these complaints. The public agent must be allowed to change the status of the demand and the citizen to monitor the progress. Local authorities should also be able to forward them to another public agent if needed.

2) Monitoring civic engagement: besides health and policing authorities, other public agents can improve decision-making by tracking civic engagement variables. For example, it must enable to provide constantly updated visualizations about denunciations hot spots, social isolation level and other available information concerning the citizen involvement in containing the virus.

[1] https://todeolho.mprn.mp.br/privacidade.pdf

3) Digital contact tracing: WHO describes contact tracing in three steps [6]: (i) identifying the contacts of the confirmed positive, (ii) listing the contacts, informing them of possible contact with an infected person and (iii) a follow-up process. Given the rate at which the virus spreads, manual contact tracing can end up being very expensive, not so scalable and more prone to notify too slowly to contain virus spreading [3]. The system should automate this process in order to notify contacts when they happen or as soon as possible. According to [4], several aspects may influence contact tracing applications:

- Nature of the model: Centralized or decentralized.
- Technique employed: Bluetooth or GPS.
- Privacy: From snoopers, other users and the government.
- Adversarial model: System behavior against attackers.
- Scalability: System behavior with increasing workloads.

4) Selective infectious testing: given the demand for cities to reopen businesses, health authorities must seek an efficient testing process to increase coverage of people likely to be infected. The platform must support health authorities with tools to filter users that have suspect symptoms, related comorbidities (e.g. diabetes cardiovascular or respiratory disease), or those who have visited virus hot zones, according to our contact tracing system. Personal data must be accessed exclusively by the health authorities and for a restricted period of time. Also, after health agents schedule tests with selected users, the platform must notify the invitation and let the user accept or decline. In accepted invitations, the indicated time should be reserved.

5) Integration with private institutions: reopening local businesses needs planning in a safe and coordinated manner. Thus private institutions must have means to interact with the system. For example, the platform must be able to show each company that employees have tested positive to protect the rest of their employees and prevent the work environment from being an aggravating factor in transmitting the virus. Private institutions interacting with the platform is important to identify which business are more safe to open and which may need restrictions.

6) Integration with third-party city apps: some cities have one or more mobile apps that is commonly used by the people, e.g. app for transportation. New apps must be able to integrate with them to achieve broader audience, avoid obsolescence and reach its purposes.

IV. The TdO platform

In this section, we describe how the TdO platform is fulfilling the requirements mentioned above and bridging a close relationship between citizens and public agents towards information exchange and better decision-making. We describe the platform's architectural design in which we managed a mobile app, a web module and an analytical dashboard. By detailing the available user roles and their current operations within the TdO, we present the components of the TdO platform for citizen cooperation deployed in RN, Brazil during the COVID-19 pandemic.

A. Architecture Overview

The platform has three interface modules, the mobile *App*, the *Web UI* and the *Dashboard*. Some functionalities are exclusive to a particular interface module, and they can be accessed by different user roles, as we detail later on this section. In the platform general architecture (see Figure 1), we separate subsystems into *Facade Layer*, *Integration Layer*, *Analytics Engine* and the *SGeoL Middleware*. The interfaces are supplied with data provided by the *Facade Layer*, which is composed by a set of REST APIs that are protected with a security mechanism. These APIs interact with the interface modules receiving and sending data to the interfaces and to the *Integration Layer*. In our design, the *Dashboard* only consumes data. Incoming data is received by the facade APIs and delivers to the integration APIs for storage. The *Integration Layer* also connects different sources of data, including *Third-party Apps*, to provide to the front facade. The *Integration Layer* also has one more level of security by standing within a private network.

To manage user access control and support efficient geographic data storage and query, we use the *SGeoL Middleware* [7]. It provides an API for a multi-application environment in which the user permission on layers of geospatial information can be managed easily. Finally, our *Analytics Engine* comprises the set of tools for implementing analytical and spatiotemporal operations, for example, digital contact tracing, individual's risk status and others. It provides to the integration layer refined results from these operations.

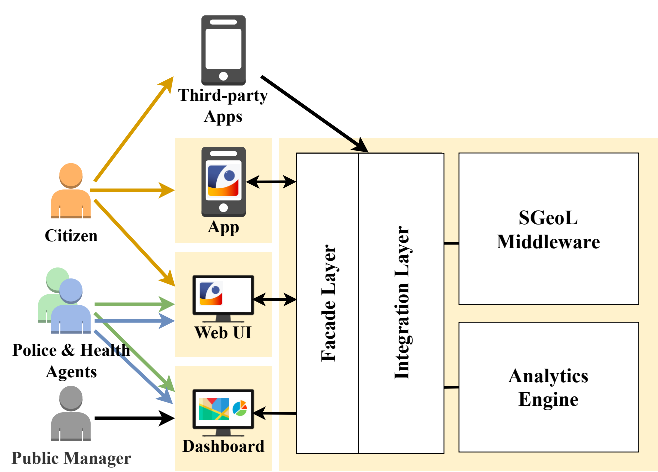
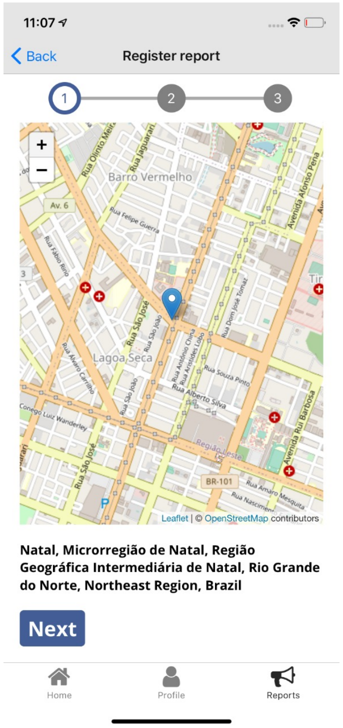


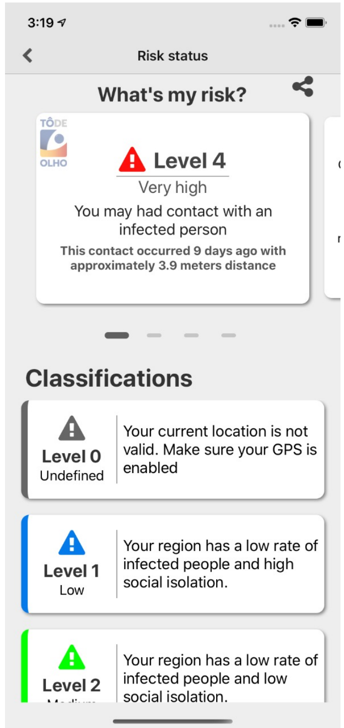
Fig. 1: Overview of the TdO components and their interactions.

B. User roles

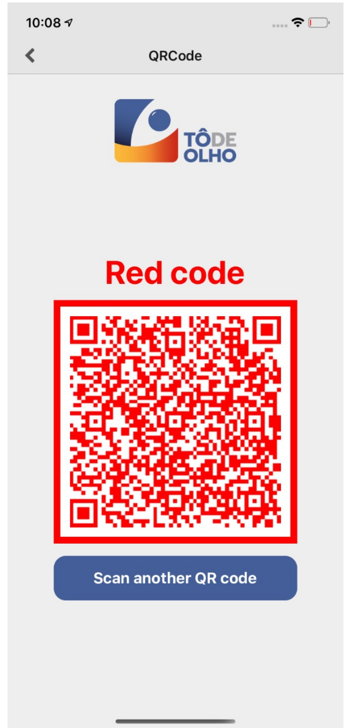
The roles in TdO can be roughly divided as citizens, private institutions and public agents, each with particular functionalities. Anyone can act as a citizen in the platform with its own personal profile. The other roles can only be registered by the TdO management staff. **Citizen** users can operate the *App*, the *Web UI* and of course, the *Third-party*



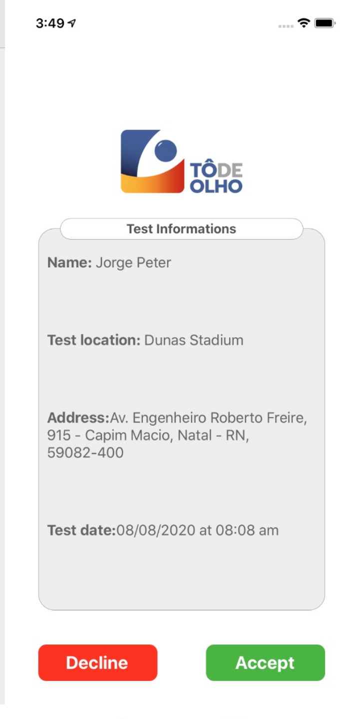
(a) Creating a denunciation, indicating its location.



(b) Status risk classification and description.



(c) QR health code in red, indicating a high risk.



(d) Invitation for an infectious test.

Fig. 2: Examples of interaction of the application's functionalities.

Apps that have a partnership with TdO. Within our ecosystem, they can (i) anonymously create denunciations with an open text field, associate its category and optionally provide photos; (ii) check status of the denunciations created; (iii) track daily information, such as about their own "risk status" (see Section IV-E), the city's social isolation level, and the number of COVID-19 cases; (iv) share this information in social media; (iv) inform symptoms and comorbidity; (v) receive, accept and decline a scheduled invitation for infectious testing and finally (vi) receive, accept and decline a request for follow-up testing by your employer. Only functionalities (iii) and (iv) request location data from the user, so the rest keep working fine if they decline to share GPS data.

With regards to the **Private institution** user, they have the same functionalities, but one more. They can consult the risk status of their employees in order to keep them at home and avoid contamination of the others. The user needs to accept the private institution request to monitor their health, so if the user does not want to share, his or her information is not shared.

While normal users interact with the platform with the *App* and the *Web UI*, **Public agent** users navigate in the *Web UI* and the *Dashboard*. In the *Web UI*, these users can (i) attend and change the status (from "opened" to "under analysis", "forwarded", "in resolution" or "closed") of one or more denunciations requests; (ii) select users to schedule infectious testing and (iii) indicates the test results of individuals. The procedure for choosing citizen users to infectious tests is described later in Section IV-F. In the Dashboard (Figure 3), public agents can visualize (iv) maps of denunciation clusters, (v) social isolation level over time in all cities and their neighborhoods and (vi) the number of COVID-19 cases in all cities.

C. GPS-based contact tracing

Our model centralizes GPS data to trace contacts with infected users and virus hot zones. To consider the contribution of environmental transmission [3], our approach is to detect a contact as the event of a spatiotemporal windowed intersection, or purely spatial, between an infected person and an non-infected user. We use data from two sources, (i) the app users locations (sampled every 5 minutes) and (ii) the addresses of all infected persons that reported first symptoms in the last fourteen days before, according to the health authorities. Firstly, the traditional spatiotemporal contact is detected when an instance of (i) intersects the space-time window of an instance of (i) listed in (ii), i.e. an user crossing an infected user that had the firsts symptoms recently. A pure spatial contact is considered when an instance of (i) intersects a spatial boundary around the residence address of (ii). We are using 30 minutes and 25 meters for the spatiotemporal window, and 25 meters for the pure spatial window.

Choosing a space-time window can be an arbitrary task that should consider the impacts of a high false-positive rate, and other rules may be necessary to avoid exaggerated amounts of

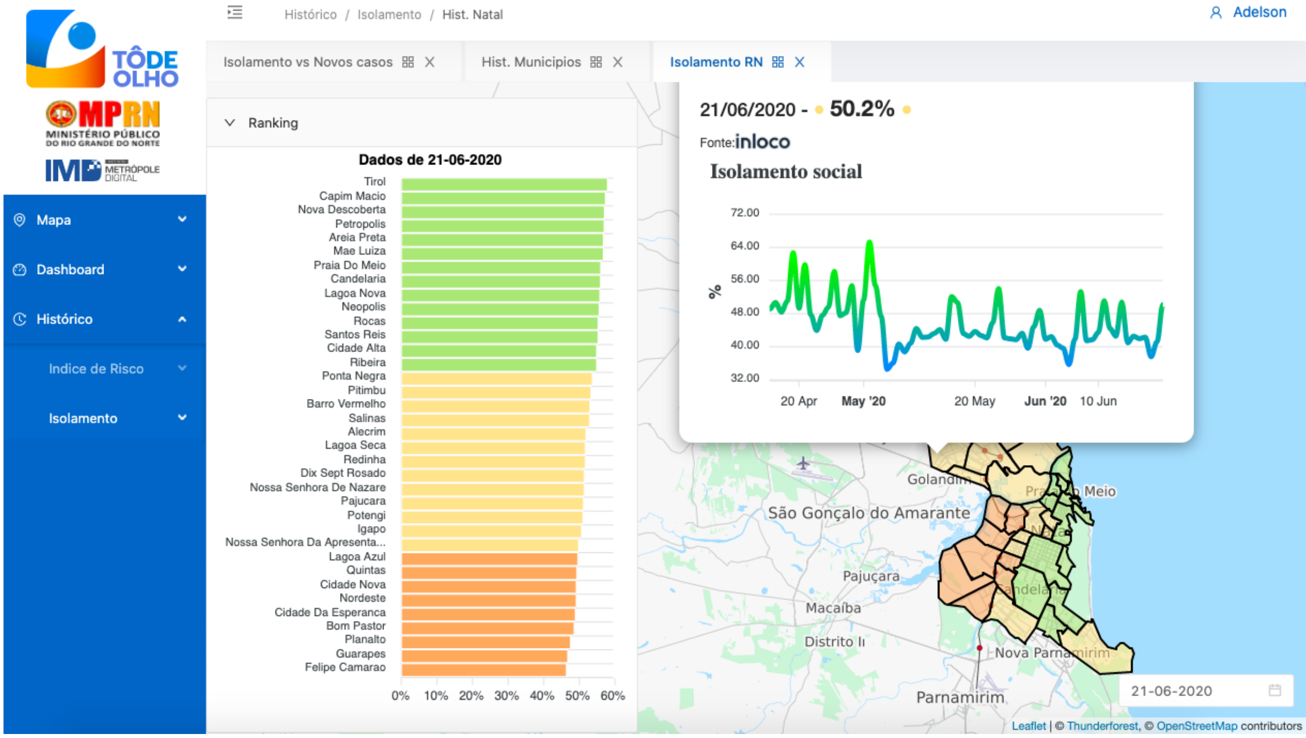


Fig. 3: Dashboard map of social isolation levels over time at neighborhood level for Natal, Brazil.

notifications. Since traditional Bluetooth-based methods may not alert when an infected person crosses a virus hot zone, the difference in the frequency of notification is significant, but it is not in the scope of this study to evaluate it. To ensure that there are not so many false positives, we only notify a contact via the app if there was more than one contact in the day and if the average contact distance was less than 30 meters. This reduced the overall amount of contact notification in average by 70% a day. Although there is not a clear and reasonable consensus on digital contact tracing methodologies and techniques, we argue that ours were design aiming to involve more citizens with social distancing and to make them avoid known dangerous trajectories. We discuss users feedback on our contact tracing approach in Section V.

Regarding privacy levels, our approach provides privacy from snoopers (L1), from other users (L2) and also partially from the government (L3), as we discussed in Section II. With regards to scalability, we currently do not manage real-time contact tracing, and we compute spatial joins of intersection between infected and users positions in batch, twice a day reporting contacts.

D. Level of social isolation

During the pandemic, one way to measure people's engagement in containing the virus is to monitor the level of social isolation. In Brazil, the mobile technology company Inloco developed a metric for spatiotemporal mapping of social isolation using location data from millions of devices. Through a partnership with MPRN, Inloco daily provides the level of social isolation on the scale of cities and neighborhoods in the main cities of the state [8]. In the state of RN, they calculate the metric with location data from more than 700,000 phones. The algorithm for producing this metric is owned by the company, but they provide a reliable privacy policy. The collection of location data by Inloco is made without directly linking the personal identification with the stored coordinates, so they claim the data is anonymized. By updating the level of social isolation on a daily basis, all users of the TdO can have a reliable and recently updated perception of how society is involved in containing the virus. We show this metric in all interfaces, App, Web UI and Dashboard. Figure 3 illustrates Dashboard screen with the level of social isolation in a neighborhood of Natal, the state capital.

E. Risk status and QR health code

To inform infectious risk for individual users in TdO represent, we compute a simple metric with the current city's social isolation level, number of cases and whether the user had a contact in the last 14 days. It is divided in five levels: "*undefined*", "*low*", "*medium*", "*high*" and "*very high*". *Undefined* is shown when GPS not available or the coordinates indicate outside the RN state; the *low* level is shown when user region has a low rate of infected people, high social isolation and the algorithm did not identify a possible contact with infected; *medium* is triggered when the user region has a low rate of infected people, low social isolation and did not identify a possible contact with infected; *high* is displayed when the user region has a high rate of infected people, low social isolation but algorithm did not identify a possible contact with infected; and finally *very high* appear when it is likely that the user had contact with an infected person or a virus hot zone.

As another risk assessment metric, we developed the QR health code that can be green, orange or red. When a user has a contact, or while he/she is infected, there will be a red code and a countdown of fourteen days. After seven days, the code changes to orange if no contacts were again found. When the countdown hits 0, or if we did not detect any contact, the user receives the green code. The QR health code is different from the risk status in the sense that it is valid as identification for public agents about users' infectious risk. For example, China has used colour-based QR health code for controlling transportation systems, but in a different context of restrictions and low algorithm transparency [9].

F. Scheduled infectious testing

Using information about users comorbidities, notified contacts, last symptoms reported and age, public agents users can select and invite users to a scheduled infectious test. The process can be summarized as in Figure 4. An invitation triggers a notification on the App, and the user can accept or decline it. After taking and attending to the test in the local and time indicated, the health agent collects and should indicate whether the tested individuals have positive results within the app. This will immediately supply the TdO databases for the contact tracing algorithm, risk status and eventually if his or her employer is registered, it will be shown for the latter to forgive him or her from work in the coming days.

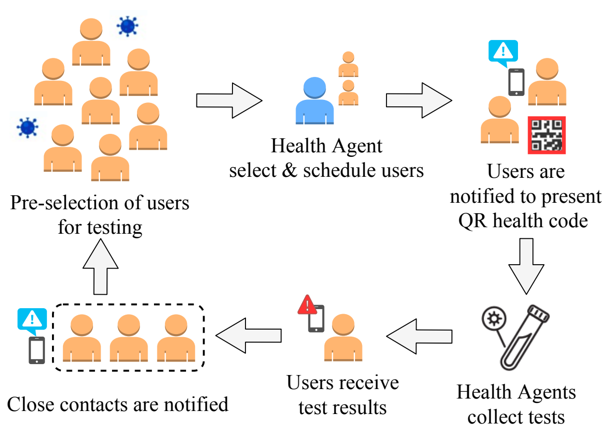


Fig. 4: Selective infectious testing workflow.

V. Discussion

In this section, we detail the general in which TdO achieved a higher audience and in what context it was deployed, compared to apps around the world and when analysed locally given user feedback.

A. Partnerships

Several partnerships were made to integrate public agents with useful features and achieve higher reach in society. As mentioned in Section 2, the TdO platform was developed within the Natal Smart City initiative, by the university and the public ministry. In this process, the state health department (SESAP/RN) was the most important external partner, providing data, helping to disseminate the platform in the state and continuously using the functionalities for health agents. However, it was not the only essential one. The company Inloco collaborated providing daily information about social isolation level in all cities of the state [8], through anonymized displacement metrics of more than 700,000 users. The state tax office (SET/RN) collaborated through the integration with its official application, which exchanges information with the TdO app about risk status. The federation of industries (FIERN) also collaborated by encouraging companies to adopt the TdO with their employees. The state public safety department (SESED/RN) was an important partner using the dashboard to distribute patrols in agglomeration sites, meeting the demands of users. The public ministry and the university are continually looking for new collaboration to integrate important stakeholders and to provide more utilities to the citizens. The platform would certainly have a modest and limited reach without partnerships between public and private institutions.

B. Comparison with related apps

Throughout the world, mobile applications have been deployed during this pandemic facing different cultural, economic, social and political scenarios.

Most apps had a modest start and evolved in terms of new functionalities, information accuracy and data protection after rigid public scrutiny. In the UK, the national health authorities developed a multipurpose app that only launched contact tracing and testing functionalities in June, and it still changed its approach to the Apple/Google framework [10] later on after the public criticized the approach taken. Throughout the pandemic, they gradually included features for QR-based check-in, free test booking and isolation countdown. Since it is the official application in the country, developed by the health authorities with readily and constant updates, their app reached massive use, with dozens of thousands of logins every day [11]. In China, Alipay's "Health Code" system reached more than 200 cities national-wide, implemented as a partnership between big tech companies and the Chinese government. The main public concern on the Chinese app is the lack of algorithm transparency [9]. Another case of massively used app was in India (with more than 50 million downloads in the first two weeks), the "Aarogya Setu" [12] was developed by the government and after public scrutiny on privacy, its source code was turn public. In many other countries, mobile applications to support citizens during the pandemic have been deployed under a different social context, and a systematic review of approaches will be of great use to public officials in the coming epidemics. **After a preliminary examination, public scrutiny, government investments and integration with active applications in the city were the main pillars to achieve massive use.**

Our platform was conceived in a more modest context, operating as a proof-of-concept in a single state of a developing country. The official coronavirus apps in Brazil were mostly focused on self-diagnostic and general information about the pandemic, such as the "Coronavírus SUS" developed by the national health ministry. In addition, the division into states in the country is an important factor with regard to the mobile applications that have emerged. Similarly to the United States, state health officials have great responsibility for maintaining local resources. Therefore, during the pandemic, many application initiatives were developed separately in states across the country, sometimes through public-private partnerships, without explicit integration with the national health ministry. There are other initiatives around the country as ours. For example, in the state of Pernambuco (PE) the Dycovid app [13], developed by a start-up and supported by the public ministry, also implemented and improved their digital contact tracing and selective testing features to support local health authorities. Dycovid only operates in PE, and TdO only in RN, as totally different projects.

Although we did not achieve massive use across the state, the 20,000 users were sufficient to have a real experience of managing a high-demand application in a pandemic. We could see, as previously discussed, that partnerships and integration with city apps were extremely important to reach more users. Although we have no direct investment from the government to develop the platform, and the public scrutiny was not as explicit as in other countries, our experience has brought other aspects that future applications may take into account, as we will discuss soon. We argue that our main contribution in comparison to related applications was the successful experience of integrating with various local institutions, through various features such as digital contact tracing, agglomeration complaints, selective infectious testing, as well as risk status and social isolation level monitoring

C. TdO for citizens

To assess the degree to which the platform supported citizens during the pandemic, we considered user feedback with an online survey. We address aspects and requirements discussed earlier in this paper. By understanding the results obtained, we evaluate the advantages and disadvantages of the decisions we make to set up the platform given the envisioned requirements.

The survey first assessed people's opinion about the level of engagement they believed the TdO provided. We asked *"1. Based on your experience, how much do you think the app has helped you to engage more with social isolation?"*. The responses were designed as a score from 1 to 5, as app rating systems. The average of responses was 3.48, with a standard deviation of 1.48. We consider this result to be reasonably positive, given that at the survey date, some of the most important TdO features had not yet been widely used, such as selective infectious testing, which was implemented on smaller cities first to validate and test implementation. Still, we are improving the platform to reach all features in the biggest cities, and this feedback will serve as a stimulus to guide future versions.

The second question we asked was to assess the transparency of the *risk status*, showed as in Figure 2b and described in section IV-E. Since it was a heuristic methodology to provide citizens with an indication of the risk they were subject to, we consider it crucial that it was simple to understand. We asked *"2. How intuitive and easy to understand is the in-app explanation about the 'Risk status'?"*. From 1 to 5, the results reached an average of 4.08, with a standard deviation of 1.23. Given the various resources in the app explaining about the *risk status*, we expected this feedback to be better. It shows that even when there is an effort to make metrics transparent, it is not a simple task to be totally understandable.

We also asked about users interactions with contact tracing notifications. First, we asked *"3. On the days that you received contact notification about your possible visit to suspected areas of COVID-19, do you believe that your trajectory may have been favourable to generate an alert?"*. As we explained in Section IV-C, our approach naturally tends to have a high rate of false positives. Of the total respondents, only 61% did not receive any notification. Of the 39% who received it, 89% said yes, the trajectory they made on the day of the notification might have been susceptible to contact. For this reason, we reaffirm that the flexibility to a relatively high number of false positives in contact tracing, especially in conditions of high environmental transmission such as in the pandemic COVID-19, can help to provide alarms and to remind the population to avoid non-essential trajectories in this period.

Still on contact tracing, we asked for those who received a contact notification about the possible feeling of panic that our notifications may be generating: *"4. If you received a notification of contact with an infected person, what level of panic sensation did you feel?"*. The responses were again accepted in a range from 1 to 5. On average, responses indicated a level of 3.29, with a standard deviation of 1.31. We believe that a too low result would not be a good indicator since this kind of notification must describe a sense of danger and alert about the trajectory made. We argue that it is important to notify a possible contact without causing too much panic, showing the danger transparently and in different ways, for example, through the risk status and the QR health code.

Furthermore, we assess users' opinions on how well the TdO has integrated public institutions during the pandemic. With answers in the same range, we asked *"5. How much do you believe that the current features of TdO (denunciation of agglomerations, contact tracing, scheduling tests and social isolation data) are capable of satisfactorily integrating citizens with the city hall, health and safety authorities?"*. The responses indicated an average score of 3.55, with a standard deviation of 1.52.

In fact, these results may indicate that TdO's actions perform relatively well for a preliminary initiative, but that there is still a lot of room for improvement. For this reason, our final question in the survey was *"6. Today, what is the* *main limitation of TdO?"*. Among several options, the top three most indicated were "The low frequency with which the data is updated" (32%), "Answering my report does not happen" (20%), followed by "The slowness or failures of the application" (12%). The first limitation we understand as the main demand of the population during the pandemic, and it seems that the daily update is still not enough for them. The second demand is for more complaints, which depends on the participation and greater use of the TdO by city halls and public safety authorities. Third, users complain about the availability of the app, which is one of our primary concerns for maintenance and improvement of services.

VI. Conclusion

Smart cities have been challenged to apply ICT infrastructure to contain the advancement of the coronavirus pandemic. Currently, mobile applications have been considered the instruments to promote massive information networks and thus enable mechanisms for citizen participation in city actions. In this paper, we list the requirements that we believe are crucial to putting citizens in the loop during highly contagious epidemics. We proposed TdO, a platform to implement several functionalities to stimulate the interaction between citizens, public and private institutions. TdO platform reached more than 20,000 users in less than four months, and through iterative improvements demonstrated value for citizens of the state of RN, Brazil, through features such as contact tracing, selective infection testing, social isolation monitoring, among other metrics.

We discussed some of the effects of our platform. First, it leveraged the integration of local authorities, private institutions and citizens during the pandemic through the functionalities available and partnerships made. Then we compared our platform to related apps, describing the main differences. We described the extent to which complaints are being handled by local authorities, indicating the difficulty in engaging agents to deal with them. Finally, we discussed the feedback of some active TdO users on the various functionalities and objectives of the platform. We identified that the platform has performed satisfactorily in the opinion of the respondents, with little rejection, despite having management aspects to be improved.

Given that the pandemic has had a prolonged impact in Brazil and the growing economic obstacles to keeping people in quarantine for longer, especially in a developing country, innovations in citizen collaboration must constantly be proposed to improve the quality of life. In fact, this is not a simple task and must involve integrated actions at different institutional levels, such as the university, the government and the private sector. Sharing experiences in different parts of the world can collaborate with the development of more mature solutions. Citizen cooperation achieved with this type of application in a smart city can be the firsts prototypes for urban models and public policies based on digitally based participation and improve the city's collaborative management.

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