Assessing the level of acceptance of a crowdsourcing solution to monitor infectious diseases propagation

Matheus M. Cruz
Instituto de Computação
Universidade Federal Fluminense
Niterói-RJ, Brazil
mmcruz@id.uff.br

Roberta S. Oliveira
Instituto de Computação
Universidade Federal Fluminense
Niterói-RJ, Brazil
robertasa@id.uff.br

Augusto P. V. Beltrão
Instituto de Computação
Universidade Federal Fluminense
Niterói-RJ, Brazil
apizano@id.uff.br

Paulo H. B. Lopes
Instituto de Computação
Universidade Federal Fluminense
Niterói-RJ, Brazil
paulohbl@id.uff.br

José Viterbo
Instituto de Computação
Universidade Federal Fluminense
Niterói-RJ, Brazil
viterbo@ic.uff.br

Daniela G. Trevisan
Instituto de Computação
Universidade Federal Fluminense
Niterói-RJ, Brazil
daniela@ic.uff.br

Flavia Bernardini
Instituto de Computação
Universidade Federal Fluminense
Niterói-RJ, Brazil
fcbernardini@ic.uff.br

***Abstract* — This work presents a study for assessing the technology acceptance of a contact tracing app, also proposed by us, which is a hybrid crowdsensing application (opportunistic and participatory). The goal of the app is that users are notified if they were in contact with others infected. It also allows creating a heat map identifying streets, squares, and commercial locations to which contaminated users were, allowing more assertive hygiene actions and eliminating infectious disease outbreaks. Our methodology aimed on finding whether people would be willing to share their location, as well as their health issues related to COVID-19. It is composed by a survey for verifying the interest of the proposed application; the prototype of the application; and the use of Technology Acceptance Model (TAM). We can see that the vast majority of respondents to the first survey were interested in using a contact tracking application, even though they need to share their location and report when they become infected. In addition, the proposed RISCOVID application proved to be accepted for use by participants in the second survey.**

Keywords* — *crowdsensing, contact tracing app, COVID-19 tracking, local government, TAM

I. Introduction

Due to the novel coronavirus, many cities around the world had to implement lockdown policies and borders were closed in many countries so they could prevent the spread of the virus. The lockdown and social distancing policies affected negatively the economy causing many businesses to close their doors and resulting in high levels of job losses. On the other hand, there was no other way to avoid the implementation of those types of policies because most governments were not prepared for such a pandemic since they had never experienced such a health crisis.

Contact tracing is an important ally to help reduce the incidence of new cases of contagion [25]. Adopted for decades by healthcare organizations around the world to control the spread of infectious diseases, contact tracing allows people to be identified who were infected with the virus, isolating them early [25]. Based on this information, it is possible to stop the virus from spreading. In addition, it allows the infected people to isolate themselves and their contacts to become aware of the need to quarantine. Contact tracing is mainly used after the lockdown, that is, after the most critical phase of the contagion wave, in which countries seek to make trade more flexible and return to normality. In this phase, it is necessary to identify foci for the spread of the virus in order to avoid a second wave of contagion [26].

Contact tracing applications are being developed to assist combating COVID-19 in national and international scope. Like StopCovid in France [28], TraceTogether in Singapore [29], CovidSafe in Australia [30] and the API (Application Programming Interface) provided by Apple and Google [31]. RISCOVID'S proposal is more focused on cities, to help the local population to track and combat the spread of the virus. In all the applications mentioned above, whoever classifies the user as infected is the government health authority and the application and the data are under the management and control of federal governments. Our proposal (RISCOVID) is that the application is not under the control of the Government, but of society. A Hybrid Crowdsensing application, where in addition to automatically collecting proximity data between users (Crowdsensing Opportunistic), it also works collaboratively, where citizens themselves must inform whether they have been contaminated or not (Participative Crowdsensing). In Brazil, in the specific case of COVID-19, applications to combat the pandemic must not be under the control of government authorities. Because it is common for the government to omit or lack of transparency concerning the number of infected and deaths confirmed by COVID19 [11], [12]. However, before launching an application like RISCOVID, it is essential to evaluate the characteristics and customs of the local communities that intend to use it. It only makes sense to make a crowdsourcing application available for tracing contacts if we have the engagement of local users.

For conducting our study, we developed a methodology composed by (i) a survey for verifying the interest of our proposed application; (ii) development of the prototype of the application RISCOVID; and (iii) the use of Technology Acceptance Model (TAM), instantiated through another survey, composed by a video, a link to the prototype and some questions to assess users engagement and acceptance of the local community in using RISCOVID, a crowdsourcing application for contact tracing. We analyze potential scenarios that the application could meet to be successful in that location and we believe that the engagement and the acceptance of the technology is important to predict how this kind app would be adopted by local community. For this reason, the research investigated how many adults would be willing to share their location at different levels: without any incentives beyond those already offered by the app, which encourages only love according to the collective intelligence genome [1], with financial reward through discounts at pharmacies and at a mandatory level (where it is mandatory to have downloaded the app to receive medical care in public hospitals).

The remainder of this paper is organized as follows: Section 2 presents the theoretical framework. Section 3 describes the methodology adopted in this research. Then, Section 4 presents and discusses the results obtained. Finally, Section 5 concludes and describes guidelines for future work.

II. Theoretical Reference

The theoretical basis of our work involves the concepts of (A) Crowdsensing, (B) Contact tracing and (C) Technology Acceptance Model (TAM), which will be presented below.

A. Crowdsensing

Crowdsensing is a technique in which a large group of individuals with mobile devices capable of detecting and computing (such as smartphones, tablets, and wearables) collectively share data and extract information to measure, map, analyze, estimate or infer (predict) any process of common interest.

Devices equipped with multiple sensors have become ubiquitous. Most smartphones can detect ambient light (via cameras), noise (via the microphone), location (via GPS), movement (via the accelerometer), and distance between devices (via Bluetooth). These sensors can collect large amounts of data that are useful in several ways. For example, Bluetooth data to calculate the distance between devices, GPS and the accelerometer can be used to locate holes in cities, and microphones can be used with GPS to map noise pollution.

Based on the type of user involvement, mobile crowdsensing can be classified into two types: (1) Participatory crowdsensing, in which users participate voluntarily in contributing information. (2) Opportunistic crowdsensing, in which data are automatically detected, collected, and shared without the user's intervention and, in some cases, even without the user's explicit knowledge [3], [4].

Taking advantage of the ubiquitous presence of powerful mobile computing devices (especially smartphones) crowdsensing has become an attractive method for companies that want to collect data without making large-scale investments. As in the specific case of “contact tracing” applications developed to combat COVID-19.

B. Contact tracing

A download and authorization. With two actions, the smartphone can send you a notification to say that you were close to someone who is infected with the new coronavirus. This is a summary of the contact tracing system, which national health authorities can use to carry out this type of monitoring.

Recently, Google and Apple announced an unprecedented partnership to develop contact tracing application, which will be adopted by some countries. The expectation is that the application developed jointly by Apple and Google, which allows data exchanges between cell phones on iOS and Android systems, has great popular support and helps in the anonymous identification of those infected with COVID-19.

Once installed and with the user's consent, the application will only use the Bluetooth feature on the mobile phone - which exchanges wireless data - to register contact with other mobile phones that have installed and consented to the use of the app. Through Bluetooth, phones will exchange an anonymous identification key, which does not contain information about people or their smartphones. This code will be stored in the device's memory. If the owner of any of these cell phones tests positive for the disease, the national health authorities must insert the information into the application, which will analyze the keys stored in the memory and notify the cell phones corresponding with this data: the day the contact occurred, how was the contact and how strong was the Bluetooth signal of the contact as shown in Fig. 1.

However, questions and challenges arise regarding trust in the institutions, public or private, responsible for processing data that contains personal information of citizens. These suspicions and inquiries are not intended to prevent the use of data to combat the pandemic, but to assist in establishing safeguards so that there is a balance between individual and collective interests, in addition to increasing the confidence of society and institutions in processing data for purposes sanitary facilities, facilitating this activity to be carried out in the most effective way possible [9], [10].

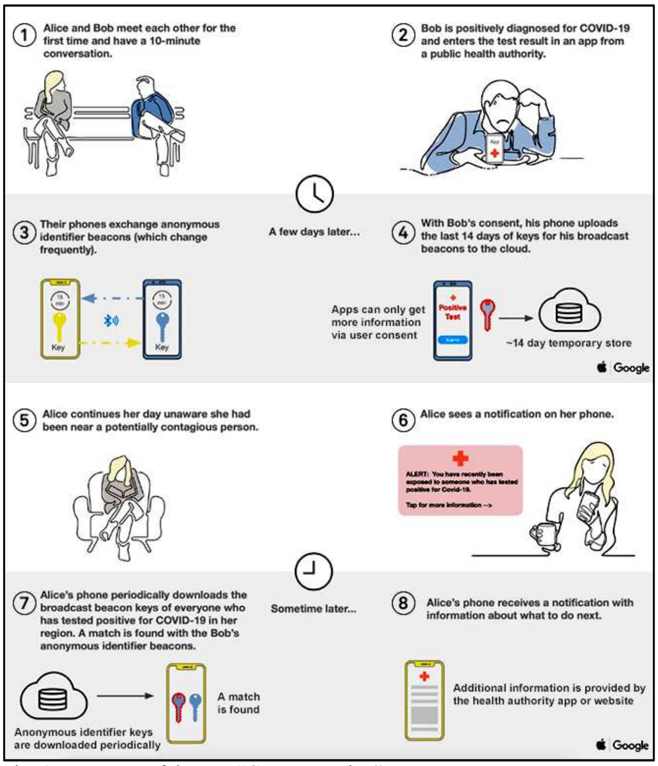

Fig. 1. Use case of the app “Contact tracing”
Source: Apple | Google

C. Technology Acceptance Model (TAM)

Davis [13] introduced the technology acceptance model (TAM). This model aims to assist those responsible for implementing information systems to assess their current and future acceptance. There are studies that use TAM, for example, to evaluate the use and acceptance of word processor [22], to verify perceptions of compatibility between systems [35], to evaluate emotional reactions to the use of computers [19], to evaluate the use of productivity packages [16] and to support software producers who want to check the demand for new ideas and products [15].

TAM is an adaptation of the Theory of Rational Action (TRA), coming from psychology, and modified specifically to create models of acceptance of information technology [36]. According to Davis [37], the objective of TAM is to enable an explanation of the determinants of the use of computers, capable of contemplating user behaviors through a wide range of technologies and populations. The model takes into account that external stimuli influence personal attitudes, indirectly influencing their beliefs about the consequences of having that behavior.

People tend to use technology to improve their performance at work - perceived usefulness[13]. However, even if that person understands that certain technology is useful, its use may be impaired if is too complicated, so that the effort does not compensate for the use - perceived ease [13]. Therefore, TAM is based on three constructs: perceived utility, perceived ease of use, and Behavioral Intention to use, as shown in Fig. 2 [13].

Individuals will use a certain technology if they believe that this use will provide positive results, focusing on perceived ease of use (Perceived Ease of Use), perceived utility (Perceived Usefulness), and Intention to Use (Behavioral Intention to Use).

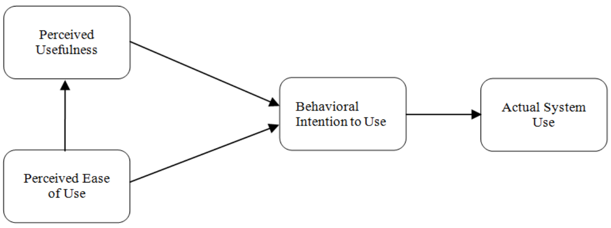

Fig. 2. Technology Acceptance Model Diagram
Source: Davis [13] and Venkatesh [17]

As the model is behavioral, it can only refer to issues directly related to the user and their perceptions about the use of the system. Therefore, constructs must be developed to capture personal opinions [14]. This model is useful to identify why users do not accept a particular system or technology and, consequently, implement the appropriate corrective steps [13], [15].

In each constructor, items (or questions) are defined in order to measure them. The items were initially defined by Davis [13], [15], [37] but were later adapted by several authors according to the type of technology to be evaluated, as presented in the previous research [16]-[22], [24], [35], [36].

III. METHODOLOGY

In order to investigate the existing technological tools to combat COVID-19, it was decided to carry out a brief literature review on the topic. The literature review consisted of a survey carried out in the Scopus and IEEE Digital Library databases on the subject. From the databases, it was possible to identify the applications already developed and their main weaknesses and points for improvement, as presented below in Related Works.

After this step, we developed a methodology composed by three stages: (i) a survey for verifying the interest of our proposed application; (ii) development of the prototype of the application RISCOVID; and (iii) the use of Technology Acceptance Model (TAM), instantiated through another survey, composed by a video, a link to the prototype and some questions to assess users engagement and acceptance of the local community in using RISCOVID, a crowdsourcing application for contact tracing. We conducted Stage A sending our survey for different Brazilian cities. The objective of the survey was to verify the users' interest in using the proposed application, their agreement to share their location, and declare themselves contaminated if they were infected. The result of the survey showed the interest and agreement of the participants, which leaded us to conducting Stage B, aimed to developing the app RISCOVID prototype. We conducted Stage C for assessing acceptance of the use of the prototype following the technology acceptance model (TAM) already established, which consists of the application of a quantitative method, from a data collection through a survey.

A. Related Works

There are currently at least 47 contact tracing applications available around the world [32]. China [5], Australia, South Korea, and Singapore are examples of countries that have adopted this type of technology[6]. In Canada, the COVI application was developed, which uses machine learning to carry out analyzes that intend to assist the management of public health policies [7]. And France continued with research to develop its application, called StopCovid.

Besides, Apple and Google occupy a prominent place in the current scenario, as they control two major operating systems (OS) for smartphones (iOS and Android, respectively) [34]. It would be impossible for phones using these two OS to communicate without the agreement of these companies [33]. Therefore, the union of this two big American technology companies has allowed many governments to make contact tracing applications available. The spreadsheet[1] provided by MIT Technology Review presents in detail each of the existing contact tracing applications.

B. Verification of Interest in the Proposed Application

At this stage, a survey of interest was carried out with the Brazilian local population to verify the interest in using the proposed application. Standard questions were asked, for example, the participant's gender, age, education, income and place of residence. This way, the applied questionnaire[2] allowed to categorize the types of participants according to demographic data. We used the Likert scale in the questionnaire, which is a commonly used type of psychometric response scale.

[1] MIT Technology Review's Covid Tracing Tracker DB

[2] First Survey link: https://bityli.com/kp9Dj

The main objective of the questionnaire was to assess whether the participants were willing to share their location and declare themselves contaminated when they are, to cooperate with a greater purpose, which is to combat the spread of COVID-19. For this, questions were asked, for example, it would be important for you: a) know how many infected people you crossed; b) know how many infected people have passed through a given location. It was also asked, what is the probability that: a) you share your location; b) inform if you were infected; c) share your location if the app gives you a pharmacy discount. The results and discussions obtained from the questionnaire are expressed in Section IV.

C. *Development of the Prototype*

This research step consisted of developing a front-end so that users could see what the application will look like. Uizard[3] was used, a graphical interface tool for designing the front-end. Fig. 3 shows the login and location sharing interfaces for the developed prototype.

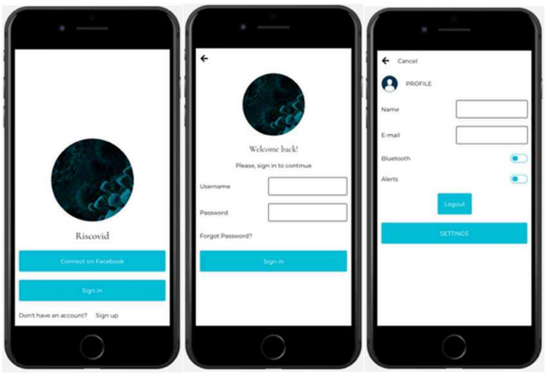

Fig. 3. Login and Sharing Location.

The prototype also allows the user to carry out the procedure of declaring himself contaminated according to Fig. 4.

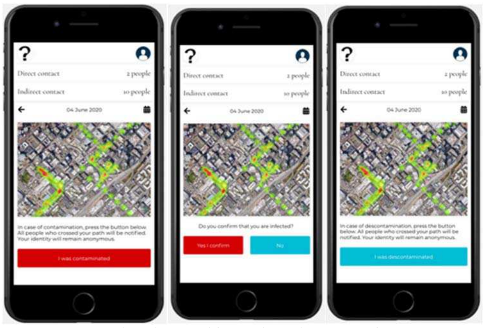

Fig. 4. Contamination Self-Declaration Interface.

A link to access the RISCOVID prototype was made available to the participants of the second survey for evaluation and assistance in answering the questionnaire. In addition, a video demonstrating the application's functionalities was also made available in the survey. The prototype, the video (available in Portuguese only) and other artifacts generated in the research are available on GitHub[3].

D. *Application of the Technology Acceptance Model (TAM)*

In this last step of the developed methodology we applied the TAM method to assess the acceptance of the proposed RISCOVID application.

We prepared the second survey[4] for data collection seeking to trace the participant's perceptions of RISCOVID. Convenience sampling [38] was used. A specific group of participants who reported an interest in participating in the second stage of the research was selected. In the first survey, participants were asked if they were interested in continuing to participate in the survey. Therefore, we focused the second survey on these participants. E-mails with the survey link were sent to those participants. The clear advantage of this strategy is that, of all sampling strategies, convenience sampling is the easiest, least time-consuming and least expensive to implement, perhaps explaining its popularity in development research [38]. Regarding its disadvantages, results that derive from convenience sampling have known generalizability only to the sample studied. Thus, any research question addressed by this strategy is limited to the sample itself. Even aware of this limitation, due to the time available, we opted for Convenience Sampling. In addition, according to Van der Bijl-Brouwer [39] when proposing a method for designing solutions to the Public Sector, she says that the scenarios describe how people want to interact with a solution in a specific use context. And when proposing a solution, consider as many scenarios as possible. For each identified scenario, successive interactions are carried out in the solution to be proposed. Considering this model, our research took into account the scenarios and contexts described only by the survey participants. New interactions, which expand and identify other types of scenarios and contexts for the proposed application are also limitations of our work.

Primary data were collected, composed mainly of closed questions using a 5-point Likert scale. The survey contained a brief introduction of the institution and the researchers who carried out the study, the research objectives, a video[5] demonstrating the prototype developed explaining and showing its functionalities, a link to access the prototype[6], and instructions for filling it out. It is important to note that before answering the second survey, participants should watch the demonstration video[5] and browse the RISCOVID prototype[6].

To measuring each of the constructs (perceived utility, perceived ease of use and intention of use), 6 items were defined. The items came from previous research on the TAM model, especially from Davis [15] and Venkatesh [17], and modified to represent the context of a contact tracing application.

To measure the "perceived utility" by users for the application, the following items were adopted (considering that sharing location and report when they become infected are premises of the application) :

1. RISCOVID would let me know if I had contact with infected people;
2. RISCOVID would allow me to identify how many infected people entered a given location;

[3] https://uizard.io/
[3] GitHub link: https://bityli.com/e5QsV
[4] Second Survey link: https://bityli.com/7A7zD
[6] Demonstrating Video of RISCOVID: https://youtu.be/AU-f-k2PqqE (Available in Portuguese only)
[7] RISCOVID Prototype: https://app.uizard.io/p/vFzhQ8EG9

3. RISCOVID would allow me to identify how many infected people would pass on a given street;
4. The use of RISCOVID would allow the Government to be more assertive in the sanitization of public areas;
5. Using RISCOVID would help the population to monitor the spread of the virus in a transparent way;
6. RISCOVID could be adopted as a tool to combat COVID-19 by Municipalities;

To measure the "perceived ease of use" by users for the application, the following items were adopted (considering that sharing location and report when they become infected are premises of the application) :

7. Learning to use RISCOVID would be easy for me;
8. I would find it easy to use RISCOVID'S features;
9. My interaction with RISCOVID would be clear and understandable;
10. I would consider RISCOVID flexible to interact;
11. It would be easy for me to become skilled in using RISCOVID;
12. I would consider RISCOVID easy to use;

To measure the "intention of use" by users for the application, the following items were (considering that sharing location and report when they become infected are premises of the application):

13. I see myself using RISCOVID;
14. I intend to share my location;
15. I intend to report, anonymously, if I am infected;
16. I would use RISCOVID more if it were easier to use;
17. I would use RISCOVID more if I didn't need to share my location;
18. I would use RISCOVID more if I didn't need to inform that I am infected;

IV. RESULTS AND DISCUSSION

A. First Survey Data Analysis

Participants (N=201) were recruited via social media and received no compensation to answer the first survey. The study was fully conducted online and the survey was made using Google Forms. Participants were asked a set of quantitative questions (a) to give an understanding of their demographic characteristics, such as, age range, location (city), education degree, and income range; (b) to understand what features they think would be important on an app that monitors COVID-19 cases and contact between people; and (c) to understand how likely people would be to share their personal information such as location and health status. The last set of qualitative questions were made (d) to understand if there were any compensation not mention before that would make them share their data and if they had any questions or concerns within the topic approached on the survey.

a) Demographic characteristics: The survey received answers from participants located in different cities distributed throughout 6 states in Brazil. The age range of the participants are distributed as follows: 63% (N=127) of the participants reported to be between 18 and 40 years old, 27% (N=55) of the participants reported to be between 40 and 60 years old, 8,5% (N=17) of the participants reported to be above 60 years old and 1% (N=2) of the participants did not want to report their age range. The results on Education Degree of the participants are as follows: 1% (N=2) of the participants reported to be on the Elementary School, 14% (N=28) of the participants reported to be on the High School, 84% (N=169) of the participants reported to hold a Degree on the Higher Education Level and 1% (N=2) of the participants did not want to report their level of education. The results on Income Range of the participants are as follows: 11% (N=22) of the participants reported to earn less than a minimum wage (U$180 / month), 32% (N=65) of the participants reported to earn between U$180 and U$540 per month, 21% (N=42) of the participants reported to earn between U$540 and U$900 per month, 25% (N=51) of the participants reported to earn above U$900 per month and 10% (N=21) of the participants did not want to report their monthly income. Considering that R$ 1 was worth U$ 0.18 in July 2020 when the research was taken.

b) App features questions (Fig. 5): More than 50% of the participants said they think it is important or very important knowing how many infected people they met, knowing how many infected people have passed through a given location and knowing a commercial spot that had a great flow of contaminated people.

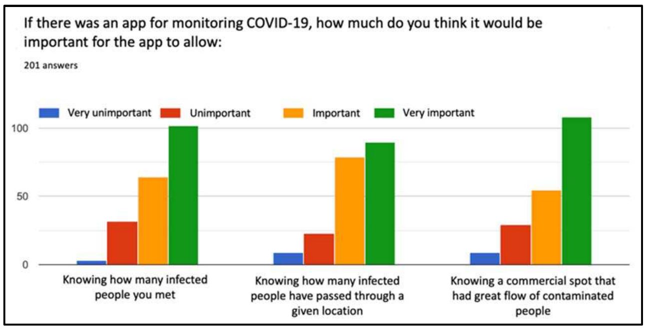

Fig. 5. App features questions

c) Data sharing question (Fig. 6): More than *65% (N=132)* of the participants said they are likely (N=49) or very likely (N=83) to share their location even without any reward. When we offer a reward, this percentage increases even more. If we offer discounts at pharmacies more than 71% (N=144) of the participants said they are likely (N=74) or very likely (N=70). When we asked if it was mandatory to share the location to enter commercial establishments more than 73% (N = 148) of the participants said they are likely (N=79) or very likely (N=69).

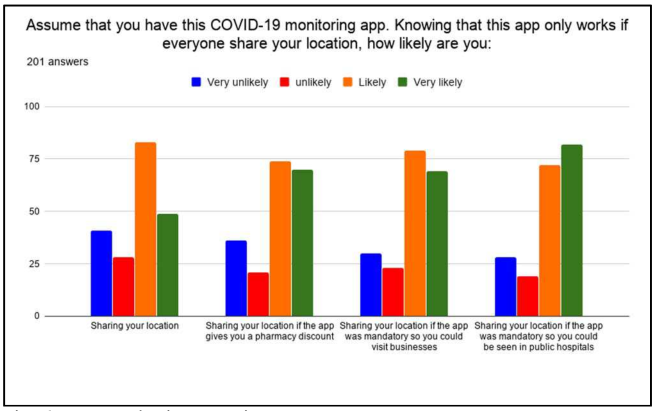

Fig. 6. Data sharing question

And finally when we asked if it was mandatory to share the location to have access to the single health system, more than 76% (N=154) of the participants said they are likely (N=72) or very likely (N=82).

We can observe in Fig. 7 that of the 69 participants who answered that it was unlikely or very unlikely to share their location, many of them changed their opinion when we offered some type of incentives. For example, if we offered discounts at pharmacies, 33,33% (N=23) of participants said it would be likely or very likely to share their location. If location sharing was mandatory so that they could enter commercial establishments or be served by the unified health system, 46,38% (N=32) of participants changed their responses to likely or very likely.

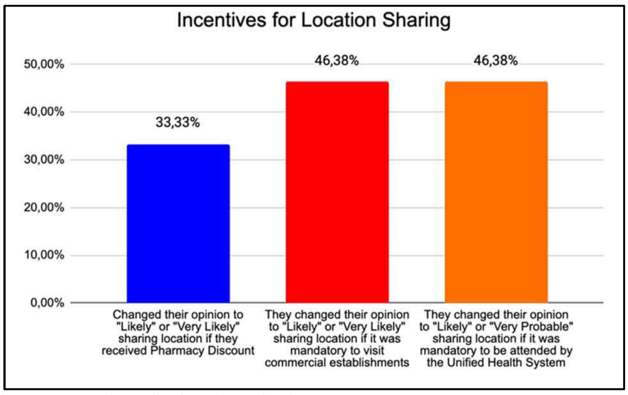

Fig. 7. Incentives for location sharing

d) Qualitative questions: 18% (N=37) of the participants said they would not share their location and/or their health condition even if the data is anonymized. 3% (N=8) of the participants raised concerns about the data privacy and 3% (N=8) of the participants criticized the question that suggested mandatory use of the app so people could be seen in public hospitals. One of the participants even compared the mandatory use with a dictator government and 1% (N=3) of the participants raised concerns about social issues such as the exclusion of people that do not own a smartphone.

Location sharing is one of the most important information RISCOVID needs from users. The non-parametric Fisher exact test was applied to verify if any individual demographic characteristic influences the likelihood of sharing the location considering a significance level of 5%. The test works with a 2x2 contingency table, therefore income and likelihood of location sharing was grouped into two categories each: (i) Unlikely ("Unlikely" + "Very unlikely") *versus* Likely ("Likely" + "Very likely"); Low income (≤ U$540) *versus* High income (> U$540). Table I shows the contingency table.

TABLE I. INCOME RANGE OF PARTICIPANTS ON THE FIRST SURVEY

Fisher Exact Test		
Income \ Likelihood	**Unlikely**	**Likely**
Low income	36	53
High income	24	69

The p-value for testing the independence of income and likelihood to share location is 4.1% which suggests the two variables are not independent. The hypothesis testing with Age and Education against the likelihood of sharing the location was not statistically significant.

B. Second Survey Data Analysis

Participants (N=30) were recruited via social media and received no compensation to answer the second survey. The study was fully conducted online and the survey was made using Microsoft Forms. Participants were asked minimal demographic questions. A set of 18 items was presented and participants rated each item on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The age range of the participants are distributed as follows: 61% (N=19) of the participants reported to be between 18 and 40 years old, 35% (N=11) of the participants reported to be between 40 and 60 years old, 3% (N=1) of the participants reported to be above 60 years old.

The results on Education Degree of the participants are as follows: 3% (N=1) of the participants reported to be on the Elementary School, 10% (N=3) of the participants reported to be on the High School, 87% (N=27) of the participants reported to hold a Degree on the Higher Education Level. The results on Income Range of the participants are as follows: 10% (N=3) of the participants reported to earn less than a minimum wage (U$180 / month), 19% (N=6) of the participants reported to earn between U$180 and U$540 per month, 26% (N=8) of the participants reported to earn between U$540 and U$900 per month, 35% (N=11) of the participants reported to earn above U$900 per month and 10% (N=3) of the participants did not want to report their monthly income.

A reliability analysis was carried out on the second survey with the 18 items. Cronbach's α = 0.78 showed acceptable reliability. Removing any of the items individually from the survey would not affect α, as the new values ranged from 0.75 to 0.81. Table II shows the descriptive statistics of the second survey. The mean, standard deviation, median, and modes for each item is reported. Higher scores of the items indicate greater acceptance of RISCOVID, the only exceptions are the items 16, 17, and 18. The median and mode of items 4-5 are 5. This suggests that participants see RISCOVID as a tool that can be useful to the Government and population. The reported statistics of the items shows that there is a tendency towards the acceptance of RISCOVID. The items 12-15 show that majority of the participants would not only use RISCOVID but also share information about geographic location and infection. The item 17 presents the highest standard deviation and a score close to 3. This item relates the use of RISCOVID to geographic location sharing.

Fig. 8 shows the frequency distribution for the score means of all 30 participants across all items. The mean score of all participants is greater than 3 and in 23 cases its greater than 4. Even though RISCOVID seems to be accepted for use by the participants of the survey it's not correct to extrapolate the results to the general population of Brazil. The sample size is too small. From the perspective of demographic representation, only one participant has more than 60 years. The survey was applied completely online which means there is also a bias in the sample towards people with the internet.

In the work of Nees [27], participants reading an idealized (instead of realistic) vignette showed higher acceptance of self-driving cars. Participants of second survey had a link to access the prototype of RISCOVID before answering the items. This type of application only works if enough citizens use it and depends on the engagement of the users. Location sharing is a controversial topic and involves sensitive privacy issues. For this reason, it's important to study the acceptance of technology of the local community to predict if this type of app will be adopted by community.

TABLE II. ITEMS AND DESCRIPTIVE STATISTICS FOR THE SECOND SURVEY

Item	Mean	S.D.	Median	Mode
Perceived utility				
1. RISCOVID would let me know if I had contact with infected people	4.43	0.57	4.00	4.00
2. RISCOVID would allow me to identify how many infected people entered a given location	4.43	0.68	5.00	5.00
3. RISCOVID would allow me to identify how many infected people would pass on a given street	4.40	0.72	4.50	5.00
4. The use of RISCOVID would allow the Government to be more assertive in the sanitization of public areas	4.70	0.53	5.00	5.00
5. Using RISCOVID would help the population to monitor the spread of the virus in a transparent way	4.47	0.68	5.00	5.00
6. RISCOVID could be adopted as a tool to combat COVID-19 by Municipalities	4.67	0.48	5.00	5.00
Perceived easy of use				
7. Learning how to use RISCOVID would be easy for me	4.63	0.61	5.00	5.00
8. I would find it easy to use the features of RISCOVID	4.70	0.60	5.00	5.00
9. My interaction with RISCOVID would be clear and understandable	4.60	0.62	5.00	5.00
10. I would consider RISCOVID flexible to interact	4.37	0.72	4.00	4.50
11. It would be easy for me to become skilled at using RISCOVID	4.57	0.73	5.00	5.00
12. I would consider RISCOVID easy to use	4.63	0.72	5.00	5.00
Intent of use				
13. I see myself using RISCOVID	4.10	1.03	4.00	4.00
14. I intend to share my location	4.17	1.12	4.50	5.00
15. I intend to report, anonymously, if I am infected	4.20	1.30	5.00	5.00
16. I would use RISCOVID more if it were easier to use	2.97	1.22	3.00	3.00
17. I would use RISCOVID more if I didn't need to share my location	2.47	1.50	2.50	1.00
18. I would use RISCOVID more if I didn't need to inform that I am infected	1.57	0.94	1.00	1.00

Note: Second survey (N=30) items rated on a Likert scale with end anchors 1 = "strongly disagree" and 5 = "strongly agree"

Although important, the guarantees of safety, confidentiality and privacy of user data was not the focus of our research. At this stage of the study, we limited ourselves to informing users that their data would be preserved and their personal identification not exposed, but for the time being we have not proposed a solution on how to implement this.

Fig. 8 shows the boxplot of scores for all 18 items. Items 16, 17, and 18 were reverse-scored. The participants appear to accept the use of RISCOVID with scores of 4 or 5 with the exception of items 16 and 17. Item 14 have four participants with outlier score lower than 3, showing the aversion of some participants to the idea of sharing location. And, as shown in Fig. 7, this aversion may be overcome in some cases by providing incentives for users to share their location.

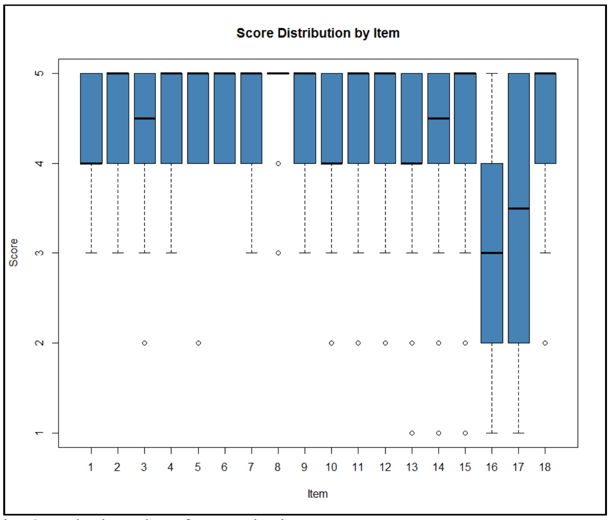

Fig. 8. The boxplot of scores by item

V. CONCLUSION

This work proposed an approach to investigate the interest, engagement and acceptance of the local community in the use of a crowdsourcing application for tracking contacts. Our methodology was composed by three main activities: application of a survey for verifying the interest of our proposed application; development of a prototype of the application RISCOVID; and use of Technology Acceptance Model (TAM), instantiated through another survey, composed by a video, a link to the prototype and some questions to assess users engagement and acceptance of the local community in using RISCOVID, a crowdsourcing application for contact tracing.

Our results showed that the TAM methodology proved to be adequate and applicable for assessing the engagement of a local community in the use of a crowdsourcing application. However, further replication studies can be done to verify that the results are the same. We could also observe that the need to provide rewards to users was important in encouraging them to share their location, as there is a great concern when it comes to privacy. We realize that users are more willing to share their locations when a tangible reward is delivered to them.

For future work, it is important to find possible factors that increase the acceptance of the application and what kind of advantages can convince citizens to share their location. In addition, mechanisms that guarantee security, confidentiality, privacy to users' data should be studied, discussed and proposed to RISCOVID. We also suggest another data collection methodology, with a more representative sampling.

REFERENCES

[1] T. W. Malone, and M. S. Bernstein, eds. *Handbook of collective intelligence*. MIT Press, 2015.

[2] R. K. Ganti, F. Ye, and H. Lei, "Mobile crowdsensing: Current state and future challenges," in IEEE Communications Magazine, vol. 49, no. 11, pp. 32–39, Nov. 2011, DOI: 10.1109/MCOM.2011.6069707.

[3] H. Xiong, D. Zhang, G. Chen, L. Wang, V. Gauthier, and L. E. Barnes, "iCrowd: Near-Optimal Task Allocation for Piggyback Crowdsensing," in IEEE Transactions on Mobile Computing, vol. 15, no. 8, pp. 2010-2022, 2016, DOI: 10.1109/TMC.2015.2483505.

[4] B. Guo, Z. Wang, Z. Yu et al., "Mobile crowd sensing and computing," ACM Computing Surveys, vol. 48, no. 1, article 7, 2015, DOI:10.1145/2794400.

[5] H. Chen, B. Yang, H. Pei, and J. Liu, "Next generation technology for epidemic prevention and control: Data-driven contact tracking," IEEE Access, vol. 7, pp. 2633-2642, 2018.

[6] J. Morley, J. Cowls, M. Taddeo, and L. Floridi, "Ethical guidelines for Covid-19 tracing apps," Nature Machine Intelligence, vol. 582, pp. 29–31, 2020.

[7] H. Alsdurf, et al., COVI White Paper - Version 1.0 (May 18, 2020). pg 54. Available at: https://arxiv.org/pdf/2005.08502v1.pdf

[8] O. Bost. Coronavirus : la France seule contre tous avec l'application StopCovid? *RTL Group*, 2020. Available at: https://www.rtl.fr/actu/debats-societe/coronavirus-la-france-seule-contre-tous-avec-l-application-stopcovid-7800507887?fbclid=IwAR3h_2KrmFC5Ddz0auroispHhlgNcdY8koyIopywYuBlvc-kzQGCa4Qoe1c. Accessed in: 13 Jul. 2020.

[9] European Digital Rights. *EDRI calls for fundamental rights-based responses to COVID-19*. Available at: https://edri.org/covid19-edri-coronavirus-fundamentalrights/. Access in: 13 Jul. 2020.

[10] G. Mcknight. Coronavirus surveillance concerns ramp up pressure to pass federal privacy law. *Internet Governance Hub*. Available at: https://www.internetgovernancehub.blog/2020/04/10/coronavirus-surveillance-concerns-ramp-up-pressure-to-pass-federal-privacy-law/. Access in: 14 Jul. 2020.

[11] S. Kafruni. Falta de transparência tira Brasil de contagem mundial de vítimas da covid. *Correio Braziliense,* 2020. Available at: https://www.correiobraziliense.com.br/app/noticia/brasil/2020/06/06/interna-brasil,861705/falta-de-transparencia-tira-brasil-de-contagem-mundial-de-vitimas-da-c.shtml. Accessed in: 13 Jul. 2020

[12] News organizations team up to provide transparency to covid-19 data. *Folha de São Paulo*, 2020. Available at: https://www1.folha.uol.com.br/internacional/en/scienceandhealth/2020/06/news-organizations-team-up-to-provide-transparency-to-covid-19-data.shtml. Accessed in: 13 Jul. 2020.

[13] F. D. Davis, R. P. Bagozzi, P. R. Warshaw, "User Acceptance of computer technology: a comparison of two theoretical models," Manage sci., New York, vol. 35, no. 8, pp. 982-1003, 1989.

[14] A. M. Saleh. Technology adoption: a study on the adoption of free software in companies. 2004. 149 f. Dissertation (Master in Administration) -Faculty of Economics, Administration and Accounting, University of São Paulo, São Paulo, 2004.

[15] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," MIS Quarterly, Minneapolis, vol. 13, no. 3, pp. 319-339, 1989.

[16] A. Dillon and M. G. Morris, "User acceptance of information technology: Theories and models," Journal of the American Society for Information Science, vol. 31, pp. 3-32, 1996.

[17] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "User acceptance of information technology: Toward a unified view," MIS Quarterly, Minneapolis, vol. 26, pp. 425–478, 2003.

[18] V. Venkatesh, and F. D. Davis, "A theoretical extension of the technology acceptance model: four longitudinal field studies," Management science, New York, vol. 46, no. 2, pp. 186-204, 2000.

[19] H. V. D. Heijden et al., "E-Tam: a revision of the Technology Acceptance Model to explain website revisits," Research Memorandum, 2000. Available at: https://research.vu.nl/ws/portalfiles/portal/1687123/20000029.pdf. Accessed on 14 Jul. 2020.

[20] Y. Lee, K. A. Kozar, and K. R. T. Larsen, "The technology acceptance model: past, present, and future," CAIS, Berkeley, vol. 12, no. 50, pp. 752-780, 2003.

[21] A. L. M. R. Silva, "The influence of user training on the acceptance of ERP systems in companies in Brazil," 2005. 118 f. Dissertation (Master in Business Administration) Federal University of Rio de Janeiro, Rio de Janeiro, 2005.

[22] P. J. Pires, and B. A. Costa Filho, "Factors of the Technology Readiness Index (IRT) as Differentiating Elements between Users and Non-Users of Internet Banking and as Background to the Technology Acceptance Model (TAM)," RAC, Curitiba, vol. 12, no. 2, pp. 429-456, Jun. 2008.

[23] P. Legris, J Ingham, and P. Collerette, "Why do people use information technology? A critical review of the technology acceptance model," Inf. Manag., vol. 40, pp. 191-204, 2003.

[24] A. K. Yarbrough, and T. B. Smith, "Technology acceptance among physicians: A new take on TAM," Med. Care. Res. Rev., vol. 64, no. 6, pp. 650–672, 2007.

[25] S. Saurabh, and S. Prateek, "Role of contact tracing in containing the 2014 Ebola outbreak: a review," African health sciences, vol. 17, no. 1, pp. 225-236, 2017, DOI:10.4314/ahs.v17i1.28.

[26] Contact tracing to help limit second wave of coronavirus, *Public Health Agency*, 2020. Available at: https://www.publichealth.hscni.net/news/contact-tracing-help-limit-second-wave-coronavirus. Accessed in: 14 Jul. 2020.

[27] M. A. Nees, "An examination of idealized versus realistic portrayals with a self-driving car acceptance scale," in Proceedings of the Human Factors and Ergonomics Society Annual Meeting. Sage CA: Los Angeles, CA: SAGE Publications, pp. 1449-1453, 2016.

[28] Publication of the CNIL's opinion on the "StopCovid" mobile application project. *Commission Nationale de l'Informatique et des Libertés (CNIL),* 2020. Available at: https://www.cnil.fr/en/publication-cnils-opinion-stopcovid-mobile-application-project. Accessed in: 13 Jul. 2020.

[29] TraceTogether, safer together, *A Singapore Government Agency Website*, 2020. Available at: https://www.tracetogether.gov.sg/. Accessed in: 13 Jul. 2020.

[30] COVIDSafe app. *Australian Government Department of Health, 2020*. Available at: https://www.health.gov.au/resources/apps-and-tools/covidsafe-app. Accessed in: 13 Jul. 2020.

[31] Privacy-Preserving Contact Tracing. *Apple*, 2020. Available at: https://www.apple.com/covid19/contacttracing. Accessed in: 13 Jul. 2020.

[32] P. H. O'Neill, T. Ryan-Mosley, and B. Johnson. A flood of coronavirus apps are tracking us. Now it's time to keep track of them. 2020. Available at: https://www.technologyreview.com/2020/05/07/1000961/launching-mittr-covid-tracing-tracker/. Accessed in 12 Jul. 2020.

[33] R. Brandom, and A. Robertson. Apple and Google are building a coronavirus tracking system into iOS and Android. *The Verge* 2020. Available at: https://www.theverge.com/2020/4/10/21216484/google-apple-coronavirus-contract-tracing-bluetooth-location-tracking-data-app. Accessed in 13 Jul. 2020.

[34] A. Newsroom. Apple and Google partner on COVID-19 contact tracing technology. Available at: https://www.apple.com/newsroom/2020/04/apple-and-google-partner-on-covid-19-contact-tracing-technology/. Accessed in 13 Jul. 2020.

[35] P. Y. K. Chau, and P. J. H. Hu, "Information technology acceptance by individual professionals: A model comparison approach," decision sciences, vol. 32, no. 4 pp. 699, 2001.

[36] S. Al-Gahtani, "The applicability of TAM outside North America: An empirical test in the United Kingdom," Information Resources Management Journal, vol. 14, no. 3, pp. 37-46, 2001.

[37] F. D. Davis. A technology acceptance model for empirically testing new end-userinfromation systems: theory and results. Ph.D. dissertation, Sloan School of Management, Massachusetts Institute Technology, Cambridge, EUA, 1985.

[38] M. H. Bornstein, J. Jager, and D. L. Putnick, "Sampling in developmental science: Situations, shortcomings, solutions, and standards," Developmental Review, vol. 33, no. 4, pp. 357-370, 2013.

[39] Van der Bijl-Brouwer, Mieke. "Designing for Social Infrastructures in Complex Service Systems: A Human-Centered and Social Systems Perspective on Service Design." *She Ji: The Journal of Design, Economics, and Innovation* 3.3 (2017): 183-197.