INSTITUTO FEDERAL
SANTA CATARINA

CÂMPUS FLORIANÓPOLIS
DEPARTAMENTO ACADÊMICO DE SAÚDE E SERVIÇOS
CURSO SUPERIOR DE TECNOLOGIA EM GESTÃO DE TECNOLOGIA E INFORMAÇÃO

GISELE GOMES GANDIN

DESIGN AND IMPLEMENTATION OF A MOBILE APPLICATION FOR THE COVID-19 PANDEMICS

Florianópolis - SC
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Trabalho de Conclusão de Curso submetido ao Instituto Federal de Educação, Ciência e Tecnologia de Santa Catarina como parte dos requisitos para obtenção do título de tecnólogo de Gestão em Tecnologia da Informação.

Orientador:
Prof. Dr. Egon Sewald Jr.

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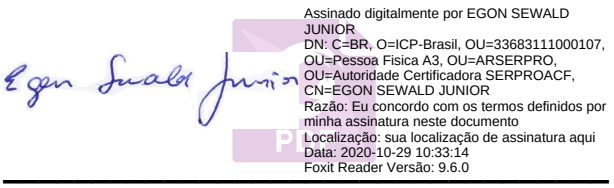
Este trabalho foi apresentado de forma pública, num processo conduzido pelo Professor Egon Sewald Jr, orientador local do projeto de intercâmbio PROPICIE 17, realizado junto à Universidade de Deusto, e professor do Curso Superior de Tecnologia em Gestão da Tecnologia da Informação do Instituto Federal de Educação, Ciência e Tecnologia de Santa Catarina. Este trabalho foi julgado adequado para obtenção do Título de Tecnólogo em Gestão da Tecnologia da Informação.

Florianópolis, 28 de outubro de 2020



Prof. Egon Sewald Jr., Doutor

Orientador

Instituto Federal de Santa Catarina

ABSTRACT

The new coronavirus has become a global issue, being considered a pandemic by the World Health Organization in early March 2020. Given the importance and magnitude of this subject, this project proposes an application in order to help the population (the common citizens) with this problem.

The application aims in a simple and clearly way to provide the users different functionalities, such as: to clarify and to help in the news spread about the new coronavirus through a news channel, capable of fetching news all over the world; to perform quickly and effective screening on symptoms to assist the users diagnosis; to show quantified data, as the number of confirmed infections, deaths and recoveries of COVID-19, making possible for the user to explore data from different countries.

The development of the previous functionalities happened through a Flutter application, in order to obtain an app for both iOS and Android (although this project have focused in Android for technical reasons), a NodeJS server, hosted by Google App Engine, and a MongoDB database to store users' data.

Lastly, after the application was released to a group of users (as testers), who have answered a survey at Google Forms, it was possible to validate the applications' usability and implement a version 1.1 of it.

Keywords: Flutter. NodeJS. MongoDB. Mobile. COVID-19.

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SUMMARY

1 INTRODUCTION

This report presents our work on eVida Lab, a research group at the Engineering Faculty at Deusto University, Spain, as exchange students of the Federal Institute of Santa Catarina, Brazil. Due to the COVID-19 pandemics that started at the end of 2019 in Wuhan, China, and which quickly spreaded all over the world in 2020, this new coronavirus was chosen to be the subject of this project because of the highly significance of this topic, and because it did impact in our own exchange program as well. As we were selected to work as interns on a project at the University of Deusto through PROPICIE 17 (an exchange program at the Federal Institute of Brazil), we were supposed to stay about three months in Spain researching and developing solutions for other topics. But as the wind of changes came, we had to come back to our own country and families, and have developed this new project remotely.

As Bill Gates said in a 2015 TED Talk, we weren't prepared for this kind of epidemic outbreak, in terms of (i) surveillance and data, (ii) personnel and (iii) treatment. Specially, we weren't qualified in these terms for a quick and coordinated response on a global scale (GATES, 2015). As we live in the Information Age, we believe people can gather better data through existing technology (such as smartphone apps) in order to improve public policy and governmental action. That said, this work aims to create a mobile application in order to help improve COVID-19 diagnosis as to provide better information for the general public.

2 STATE OF THE ART

This chapter, at first, presents an overview about COVID-19. Then, it presents some mobile applications evolving this disease. Due to the huge trembling that COVID-19 is causing around the world, many researchers are already working on solutions using mobile applications in order to reduce the damage caused.

2.1 COVID-19 OVERVIEW

In December 2019, a pneumonia epidemic, initially unknown, was detected in Wuhan, China. Soon, it was discovered to be a common consequence of a disease caused by the new coronavirus (SARS-CoV-2), highly contagious (WORD HEALTH ORGANIZATION, 2020). As this virus grows exponentially, soon it spread worldwide, and in March 2020 the World Health Organization (WHO) started to call this new scenario a pandemic.

This new coronavirus causes an infectious disease called COVID-19. On March 1st there were about 87 thousand cases of COVID-19 confirmed worldwide. On June 7th, there were more than six million and 700 thousand (WORD HEALTH ORGANIZATION, 2020). In addition to the obvious increase of the disease (which happens in an exponential scale), recent changes in diagnosis criteria have led to an increase in new cases rates, although not every country nor even every hospital inside the same country or region use the same criterias, leading everybody to bad data.

Most people infected with COVID-19 develop a mild to moderate respiratory disease and recover without the need for special treatment. Elderly people and individuals who already have previous diseases, such as cardiovascular disease, diabetes, chronic respiratory diseases and cancer, are more likely to develop worse symptoms that can lead to the need for an intensive care unit (WORD HEALTH ORGANIZATION, 2020).

COVID-19 spreads mainly through droplets of saliva or nasal discharge when an infected person sneezes or coughs, so there are a few guidelines, listed by the World Health Organization (2020) that can help prevent it, as follows:

a) To wash hands regularly with soap and water, or with alcohol 70 degrees;

b) To keep at least 1 meter of distance between people around;
c) To avoid one touching his/her own face;
d) To cover mouth and nose when coughing or sneezing;
e) To stay at home if one doesn't feel well;
f) To avoid smoking and other activities that weaken the lungs;
g) To practice physical distance, avoiding unnecessary travel and to move away from large groups of people.

Currently, there are no specific vaccines nor guaranteed treatment, but there are several studies underway evaluating these. At a society level, several governments are already deploying a shutdown for all non-essential services, and are putting everyone locked down in their own houses, in order to slow down the spread.

One of the consequences of the COVID-19 outbreak, asides from deaths and the high number of ills, is the overburden of the health care system. This happens due to the large number of patients infected with COVID-19 in a short time, in addition to the people affected by other diseases and medical conditions, who also need hospitalization. Because of this, there is also a high demand for safety equipment, causing the lack of masks, gloves and hand sanitizer for the public that needs them most: healthcare professionals.

But this pandemic isn't a sanitary crisis alone. Virtually all affected countries have suffered in their financial market as well, with a drop on assets, and subsequently negative impacts both on production and consumption due to the shortage of product distribution, mainly because of COVID-19 preventions, such as the shutdowns and lockdowns quoted above. In addition, in almost every country there are travel restrictions and with commercial flights cancelled, tourism has been weakened. These impacts, not only decrease the economy on a national level, but they impact global growth as a whole (SENHORAS, 2020).

Despite that, it has been shown that countries that have started drastic actions earlier, get recovered faster — both in economics and in epidemics.

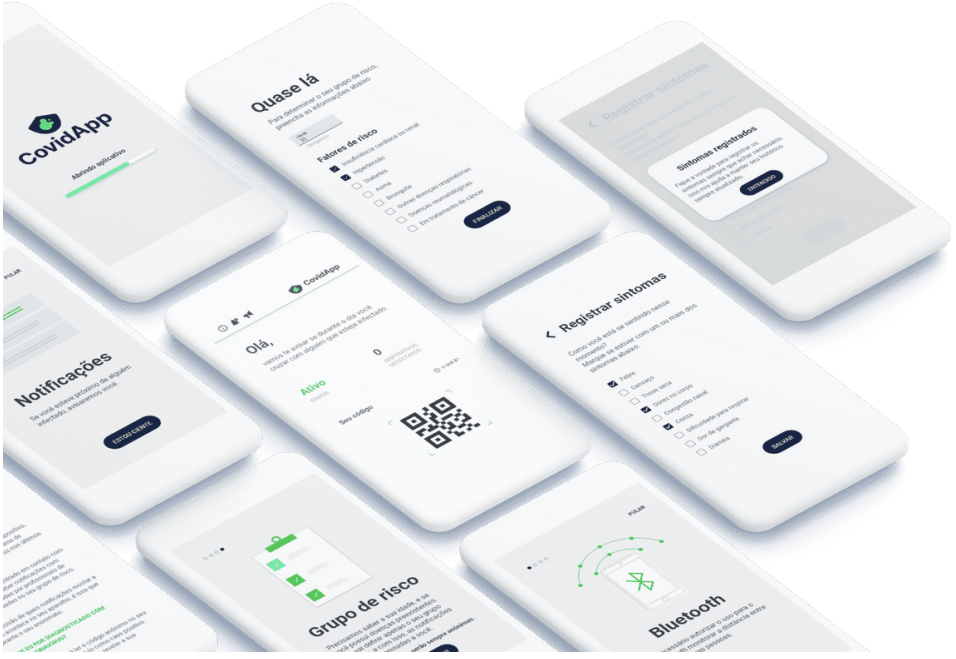
2.2 MOBILE APPLICATIONS

2.2.1 CovidApp

A group of researchers coordinated by professors Jônata Tyska and Vania Bogorny, together with a European group coordinated by Luca Mastrostefano, is developing a mobile application that allows to detect and notify people completely anonymously if they have had close contact (that is, less than two meters) with suspected or confirmed cases of coronavirus. This approach would be verified using Bluetooth technology, and then, suspected or confirmed cases would be reported by a health professional. This application intends to have a management feature from which it should be able to see reports on how the quarantine is being carried out, and the percentage of mobility of the population (CARVALHO e BOGORNY, 2020).

An image of CovidApp screens can be seen on Figure 1.

Figure 1 – Images of CovidApp



Source: Carvalho e Bogorny, 2020.

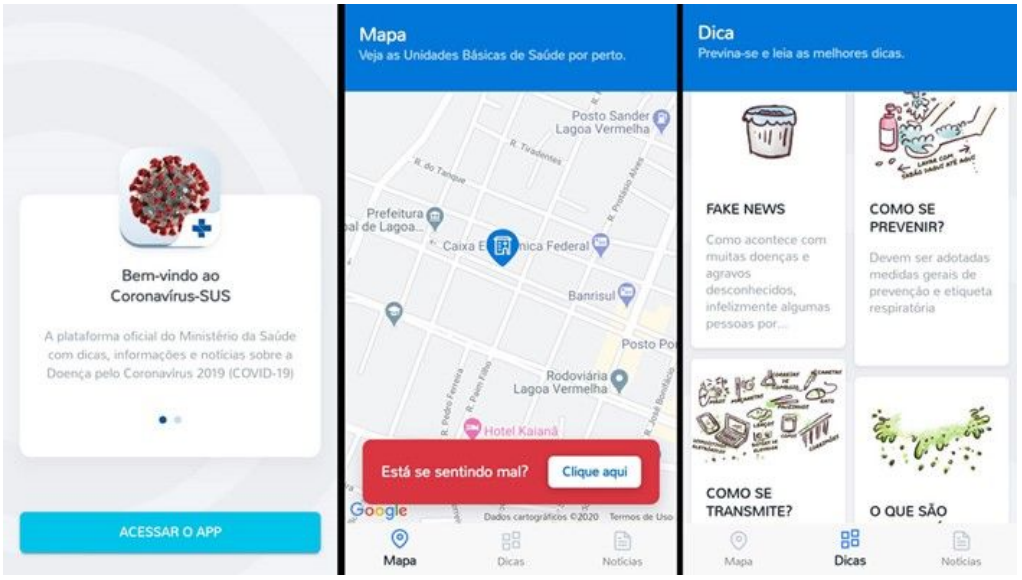
2.2.2 Coronavírus-SUS

The Brazilian government provided the Coronavírus-SUS mobile application to perform patient screening, checking if there are any symptoms presented by the user compatible with those developed by COVID-19 (GOVERNO DO BRASIL, 2020). This application contains various topics such as symptoms, how to prevent the

disease, what to do in case of suspicion or infection, and also a field with official news from the Ministry of Health about the topic, which seems really important, given the amount of Fake News presented today.

On Figure 2 there are some screens of the Coronavírus-SUS app.

Figure 2 – Screens of the Coronavirus-SUS application



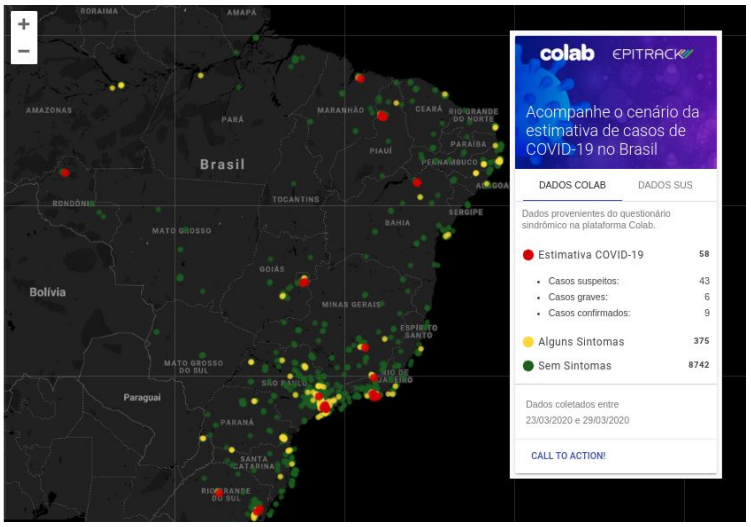
Source: Governo do Brasil, 2020.

2.2.3 Movimento Brasil sem Corona

Colab, the largest collaborative platform in Brazil, together with Epitrack, an international reference for the detection of epidemics, joined forces in order to reduce the spread of coronavirus in cities, mapping the cases of COVID-19 and the regions at outbreaks risk (BRASIL SEM CORONA, 2020). With this, they intend to help governmental health system teams to combat the coronavirus epidemic.

Through Colab application, the user answers a questionnaire stating if he has symptoms of the disease or if he had contact with someone who contracted the virus. With this data, a map is formed showing the distribution of the outbreak across the area, which is made available for public agencies use (BRASIL SEM CORONA, 2020). This map can be seen of Figure 3.

Figure 3 – Map showing the activity of COVID-19



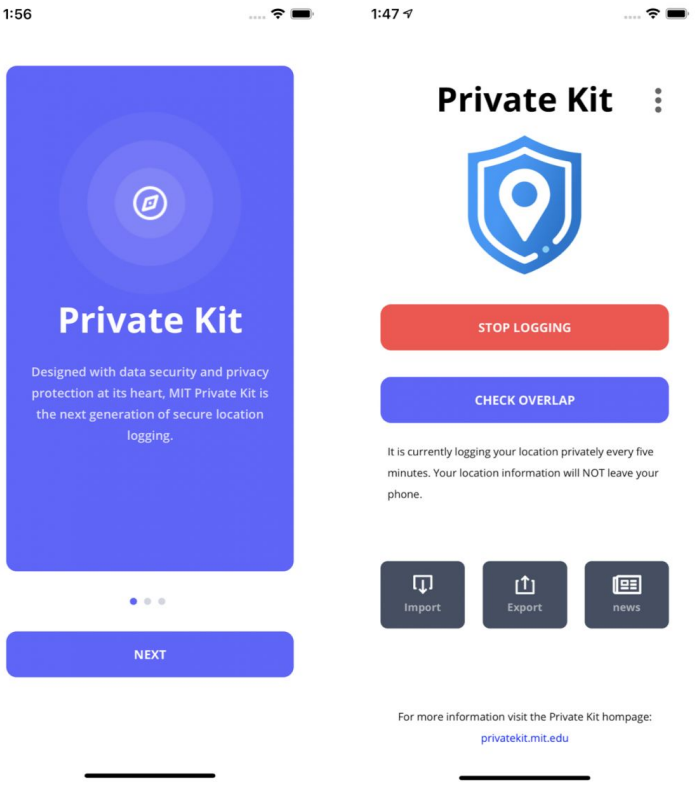
Source: Brasil sem Corona, 2020.

2.2.4 Private Kit: Safe Paths

The Private Kit: Safe Paths, created in the United States is an open source application, developed by MIT in collaboration with several researchers. In this application, the user receives a notification on his/her mobile phone if he/she is near to a person infected with COVID-19. This acknowledgment happens by Bluetooth technology and it claims to be totally anonymous for both users — the infected who sends the signal and the supposed healthy one who receives it (SAFEPATHS, 2020).

The landing page of this app can be seen on Figure 4.

Figure 4 – Screens of the Private Kit: Safe Paths application



Source: Safepaths, 2020.

2.2.5 How We Feel

The How We Feel application was developed by a team from Harvard, MIT and other renowned institutions. On it, the user may inform his/her age, symptoms and zip code, but he/she doesn't need to inform any personal information, such as name, phone number or email, because it aims to provide total privacy for the user. As the application's name proposes, the main objective of it is to know how the user is feeling at that moment, and if the answer is bad, the user may enter which symptoms he/she is feeling (SABBI LALL, 2020). This check-in is intended to last only a few seconds.

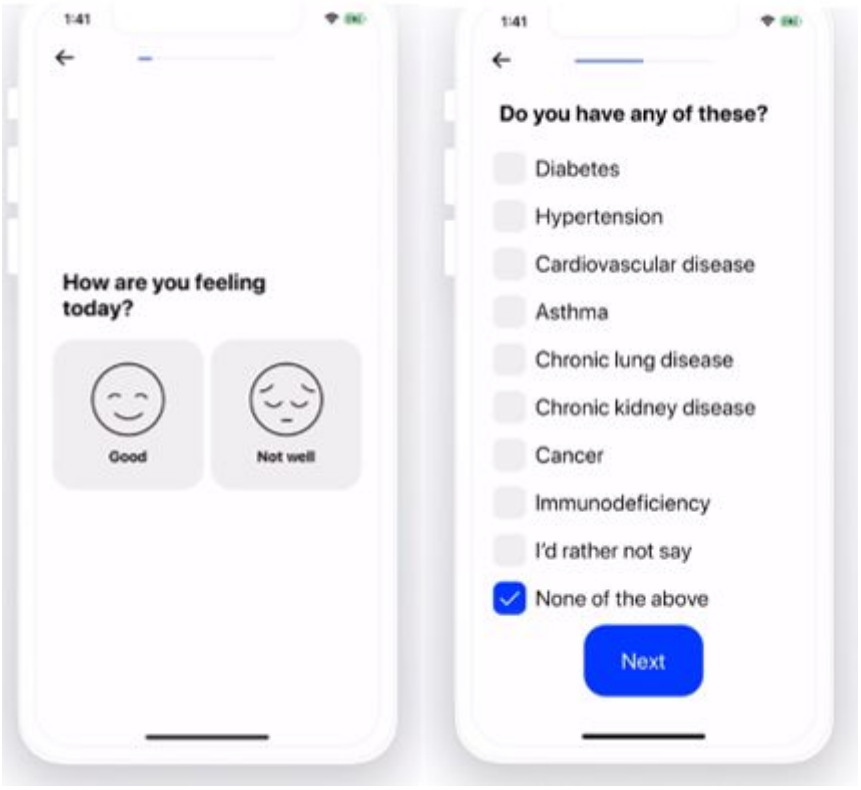
As Professor Lin have said in the application's release:

> "Our analysis could uncover epidemiological characteristics of the outbreak and how the disease spreads through communities, identify outbreak hotspots, study the time course of symptoms as the disease spreads, estimate region-specific testing needs and strategies for setting up testing

> prioritization and new testing sites, and evaluate whether interventions such as social distancing have effects on reducing transmission.” (SWEENEY apud LIN, 2020).

The main screens of this application can be seen on Figure 5.

Figure 5 – Screens of How We Feel app



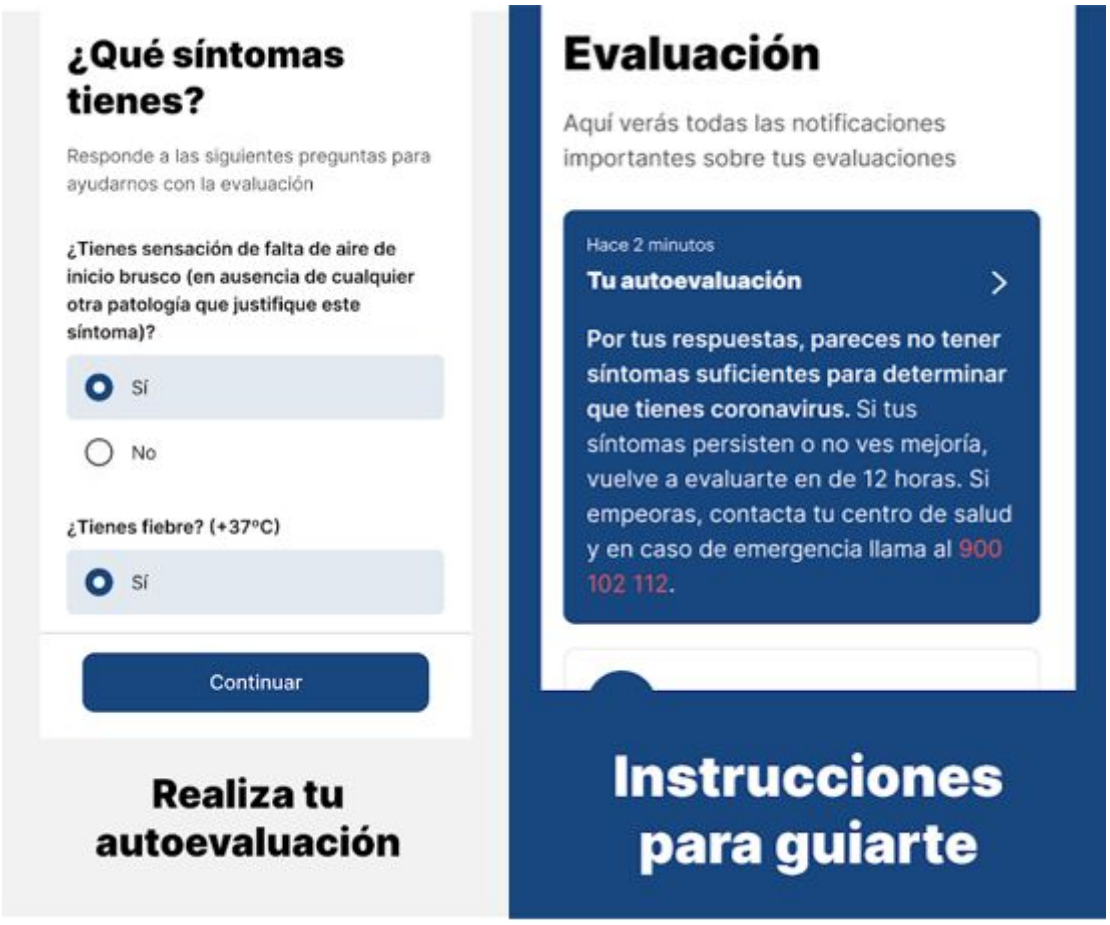
Source: How we feel, 2020.

2.2.6 Asistencia COVID-19

Asistencia COVID-19, developed by the Spanish government in a partnership with private organizations, aims to acquire information of the populations’ symptoms (related to COVID-19) in order to take policy actions. To achieve this, the user needs to fill a form about his/her symptoms, in a mobile application, or in a web site (GOBIERNO DE ESPANHA, 2020).

This application has also a social gain (besides the use for policy actions) because the developers intend to provide the code so other organizations can use it and adapt it for their needs as well. Some screens of it can be seen of Figure 6.

Figure 6 – Screens of the Asistencia COVID-19



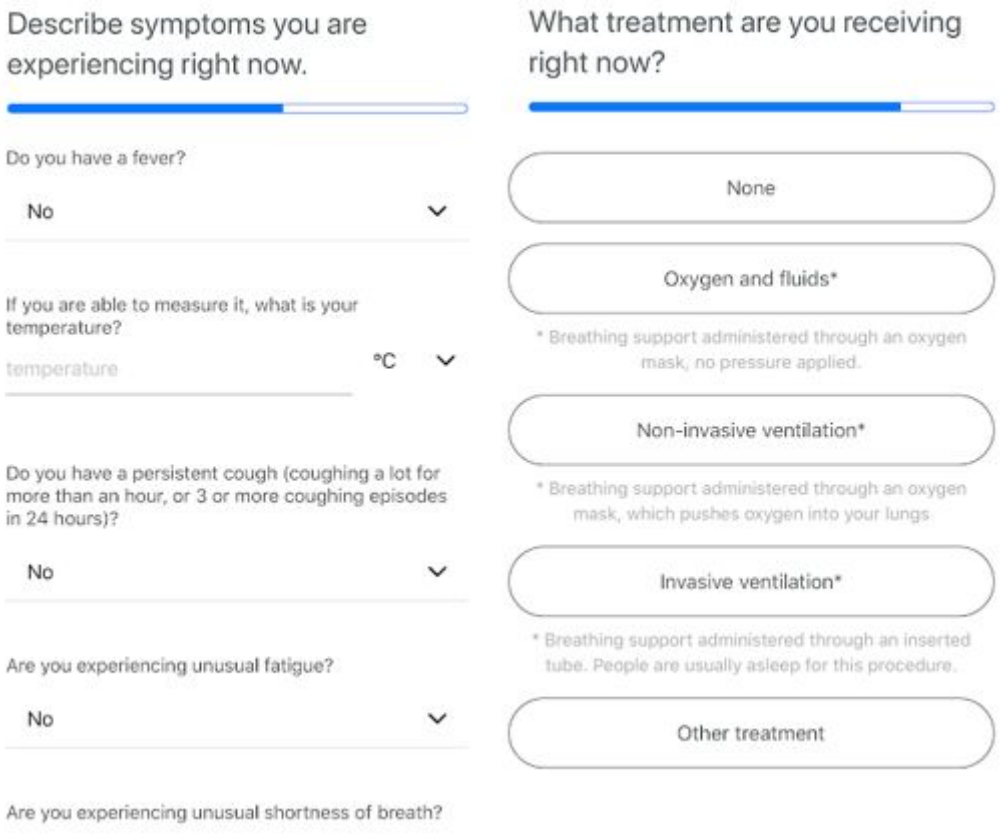
Source: Gobierno de Espanha, 2020.

2.2.7 Covid Symptom Tracker

The Covid Symptom Tracker was developed by scientists and physicians from the King's College of London and from the Guy's and St Thomas' Hospitals in a partnership with ZOE Global Ltd. In this app, as in others quoted above, the user answers a form about how he/she feels and if there are any of the COVID-19 symptoms, in order to help healthcare professionals to make policy actions with these data (COVID SYMPTOM TRACKER, 2020).

Some screens of this application are shown in Figure 7.

Figure 7 – Screens of the COVID Symptom Tracker app



Source: Covid Symptom Tracker, 2020.

2.2.8 Co100

The Co100 application, developed by the Interior and Security Ministry in South Korea, aims to ensure the population who were ordered not to leave home to really obey the governmental order.

This application not only controls the ills by tracking them using the GPS signal of their mobile phones, but also notifies users when they approach sites with infected people. Besides that, on the application the user must report his/her symptoms regularly (WRAY, 2020).

2.2.9 Alipay Health Code

Developed for the Chinese government, the Alipay Health Code is integrated to Alipay and WeChat apps, both widely used in China. In this application there is a QR-code that can be in three different colors (YE, 2020), that means:

a) Green: you're fine and can walk on the streets;
b) Yellow: you may be infected and must stay home for seven days;
c) Red: you're probably infected and must stay home for fourteen days.

Figure 8 – Example of QR-Code colors on Alipay Health Code

Source: Josh Ye, 2020.

For the user to register himself/herself on the system, he/she must inform his/her name, phone number, email, as well as health and travel history. Then, together with other data provided by the government, the application assigned the colors that can be seen in Figure 8. As written above, the user can only get out of his/her house if the QR-code is green, and this QR-code may be solicited by health system agents when the user walks on the streets, takes public transport or enters commercial establishments. When the QR-code isn't green, the user must access the application daily in order to turn it green again (WU, 2020).

And finally, a comparison between all the applications shown on this section can be seen on Table 1.

Table 1 – Comparison between apps from different countries

Apps	Origin country	Symptoms Screening	Population mobility	Infections history	Health system capacity	Good neighbourhood network	Interactive map	News channel
CovidApp	Brazil	■	■					
Coronavírus-SUS	Brazil	■		■			■	■
Private Kit: Safe Paths	USA		■					■
How We Feel	USA	■		■				
Asistencia COVID-19	Spain	■						
COVID Symptom Tracker	United Kingdom	■						
Co100	South Korea	■	■	■			■	■
Alipay Health Code	China	■	■					

Source: Designed by the author.

3 JUSTIFICATION

There are two main justifications for this project, a social and a technical, which can both be seen below.

3.1 SOCIAL JUSTIFICATION

This project stands for users access to better data. Although we live in the Information Age, our comprehension of COVID-19 is still too inaccurate. The World Health Organization, as most of the countries, don’t even know the true number of infection cases — it’s estimated to be between 10 and 20 times higher than the known confirmed cases (LI et. al., 2020). This lack of precision happens for mainly two reasons: (i) a global shortage of quick tests for the whole population and (ii) a high percentage of infected people who don't present any symptom — estimated to be 60% of all infections (QIU, 2020). Also, there is a lot of misinformation related to the COVID-19.

To improve access to information is vital to better understand any kind of problem, and is no different in the case of this new coronavirus. How many people are already infected? In what regions? What the press is writing about? What are our governments doing about it? What are the main symptoms? Does every patient feel them all? Et cetera.

So, this project aims to create a dual channel, where users can both get reliable information and also share their health status for future use.

3.2 TECHNICAL JUSTIFICATION

Smartphones are being increasingly more used. As Cristina Bröhl et. al. has shown at the International Conference on Human Aspects of IT for the Aged Population (2018), in 2015 the market was shared with desktop computers representing 62.4%, smartphones only 31.1% and tablet PCs 6.5%, whereas only two years later, desktop computers dropped their share to 44.8% of the total market, smartphones increased to 50.9% of participation and tablet PCs dropped a little to 4.3%.

So, using a mobile solution for providing better data to people (and at the same time gathering information from them) is increasingly more relevant in practical and economical terms, because people already have and use them frequently.

4 OBJECTIVES AND SCOPE

4.1 GENERAL OBJECTIVES

The general objective of this project is to design and implement a mobile application for Android, for ordinary citizens (general mobile users), in order to provide them a friendly interface for getting updated and reliable information about COVID-19 and also for sharing their health status.

It's important to note that although the app was designed for Android systems, due to the chosen technology (Dart/Flutter) it could be also implemented on iOS-based smartphones as well. This project didn't build nor test the application on iOS because there was no iPhone and MacBook to do it — and one cannot develop for iOS using another operating system on computer.

4.2 SPECIFIC OBJECTIVES

4.2.1 Technological objectives

a) Design and implement an architecture that can easily scale;
b) Design and implement an Android application;
c) Design and implement a database that can easily scale and support changes in data types;
d) Design and implement a server where users can share their information — in a format that can be easily read and used later;
e) To acquire data from reliable and update sources: from an API from John Hopkins — Center for Systems Science and Engineering (CSSE) — an API from Google News.

4.2.2 Social objectives

a) Design and implement an Application that gets reliable and updated information about COVID-19 from John Hopkins — Center for Systems Science and Engineering about the whole world or about any country in specific;
b) Design and implement an Application that gets reliable and updated information about COVID-19 from news channels worldwide;

c) Design and implement an Application where the user can share some information about his/her health status: if he/she has been tested for COVID-19, the result, and if he/she has presented any symptom.

4.3 SCOPE

This project covers both an Android Application in which the user can get information about COVID-19 and a server side to where the user can share his/her data about his/her health status related to COVID-19. This server is located online and can be searched by anybody, and also could be used for future works on the topic. As written on the Objectives section, the Persona of this project is meant to be the ordinary citizen who wants to get well informed.

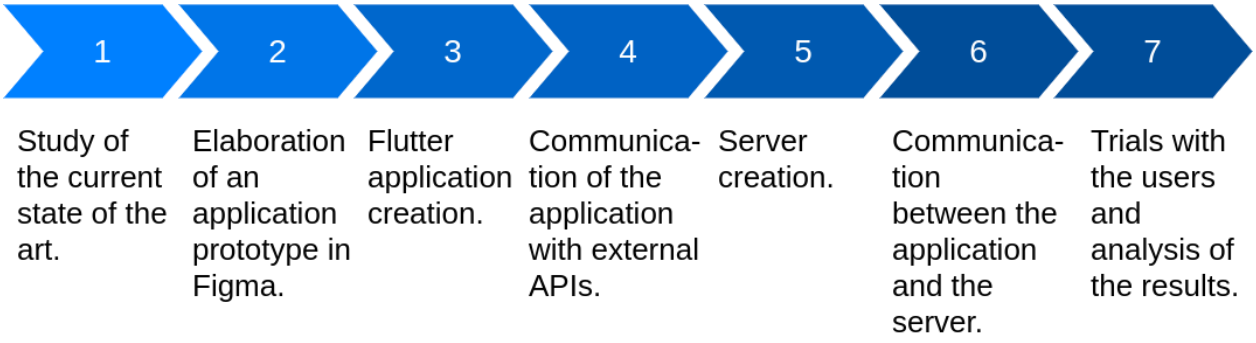
5 METHODOLOGY

This chapter presents the steps related to the project development as well as an analysis of the chosen technologies.

5.1 PHASES

On Figure 9 is shown the steps of the project, which are better explained in the following items. The project's schedule, related to these steps, are on Appendix 2, where there is a Gantt chart.

Figure 9 – Steps of the project



Source: Designed by the author.

5.1.1 Phase 1: Study of the current state of the art

a) Objective: Analyze the current state of art.

b) Results: Definition of the objectives and scope regarding the project.

5.1.2 Phase 2: Elaboration of an application prototype in Figma

a) Objective: Draw a prototype of the application's screens.

b) Results: A base of ideas for developing the screens and their flow.

5.1.3 Phase 3: Flutter application creation

a) Objective: Design and implement the mobile application based in the prototype previously designed.

- Choose among the features analyzed which are possible to implement;
- Design the screens based on the prototype made in Figma;
- Implement interactions between application screens and the user.

b) Results: The application ready with the design of the screens and possible interactions with the user.

5.1.4 Phase 4: Communication of the application with external APIs

a) Objective: Connect the app with external APIs to consume their data.
   - Connect to the API to obtain news about COVID-19;
   - Connect to the API to obtain COVID-19 case indexes in several different countries.

b) Results: Through HTTP requests, it was possible to obtain data from external APIs for use in the application.

5.1.5 Phase 5: Server creation

a) Objective: Create a server to receive symptom screening data.

b) Results: Created a server that receives the data and stores it in the database.

5.1.5 Phase 6: Communication between the app and the server

a) Objective: Design and implement the communication manager between the app and the server.

b) Results: Communication using HTTP methods for exchanging data between the application and the server.

5.1.6 Phase 7: Trials with the users and analysis of the results

a) Objective:
   - Make the application available for testing by users.
   - Get feedback from potential users about the app through a survey.

b) Results: Some of the suggestions were implemented, creating a version 1.1 of the application. The results are better explained in chapter 9.

5.2 TECHNICS

This section contains all the techniques used on this project.

5.2.1 Version Control

Version control systems are tools for the purpose of managing different versions of anything, and in the case of software development, the purpose is to manage the code itself. This kind of system keeps a track of every modification on code, and if a mistake is made, developers can “go back in time” and compare different versions in order to fix the bug (ATLASSIAN BITBUCKET, 2020).

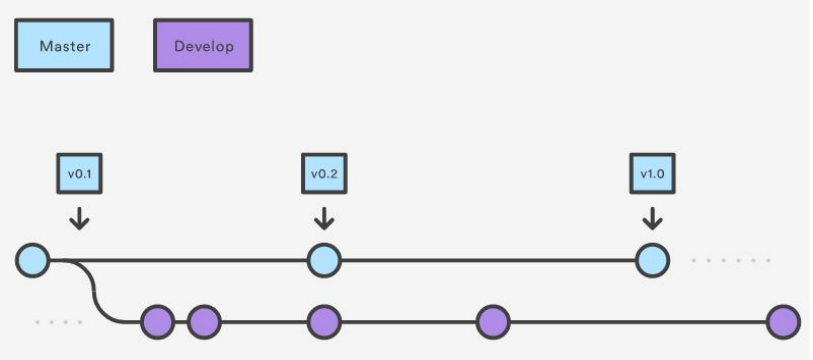
Using version control systems are vital when working in teams, because a developer can see and track what his/her partners have done, and also because it is too common for developers to work on the same piece of code at the same time. Even when they don’t work on the same files, it’s not uncommon for a change in a small part to affect the whole functionality of a feature or even the flow of the whole work. So when developers send their code to a common repository, with a version control system, it’s easier to merge all the modifications.

Of the open source version control software options, the most common are: CVS, Mercurial, Git and SVN (Subversion). In this project, it was used Git for version control, and more specifically, it was used on the GitHub platform. But how does this work?

5.2.2 Git

Git makes version control treating the code as a tree in the repository. The main branch is called “master”, and developers should create new branches when adding or modifying the code (ATLASSIAN BITBUCKET, 2020). In this project, a concept called Git Flow was used. The difference is instead of one, there are two branches that register the project's history: the master and the develop (ATLASSIAN BITBUCKET, 2020), as seen in Figure 10.

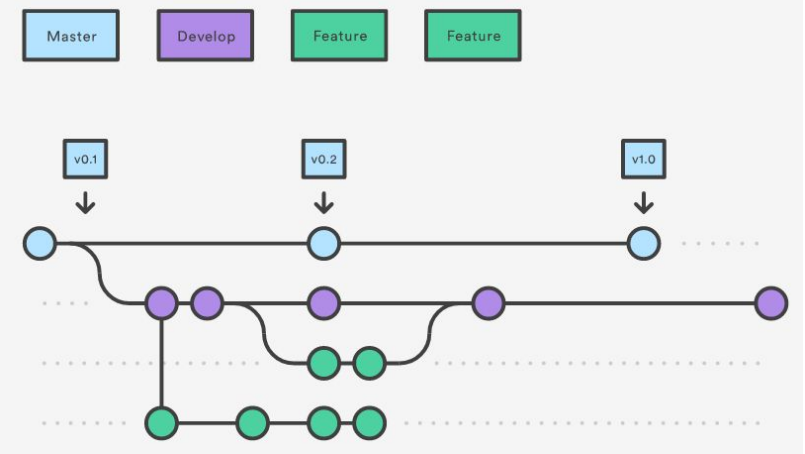
Figure 10 – Git Flow with master and develop branches



Source: Atlassian Bitbucket, 2020.

When creating a new feature, developers should do it on it's own branch. And then, send it to the repository. After code review and testing, it should be merged to the develop branch, as in Figure 11.

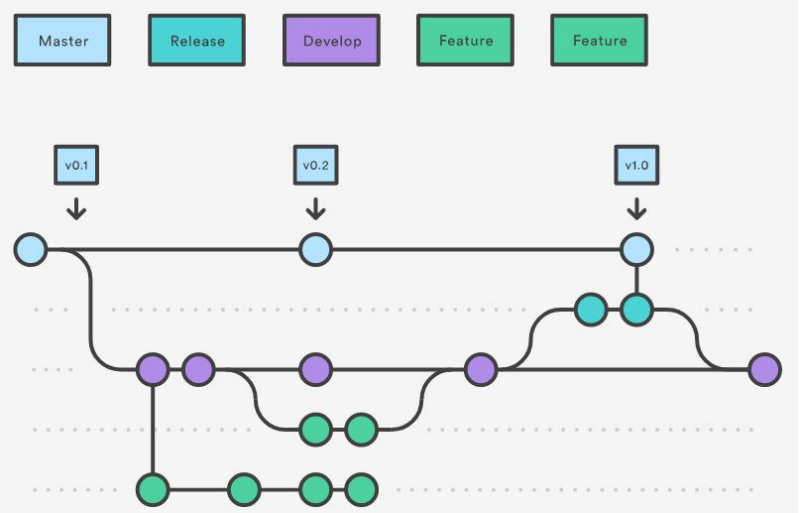
Figure 11 – Features must be pushed to the develop branch



Source: Atlassian Bitbucket, 2020.

When the application has enough features and it's ready to go to production, developers should fork a release branch from develop into master, as Figure 12 shows. This helps to keep a reliable code on production.

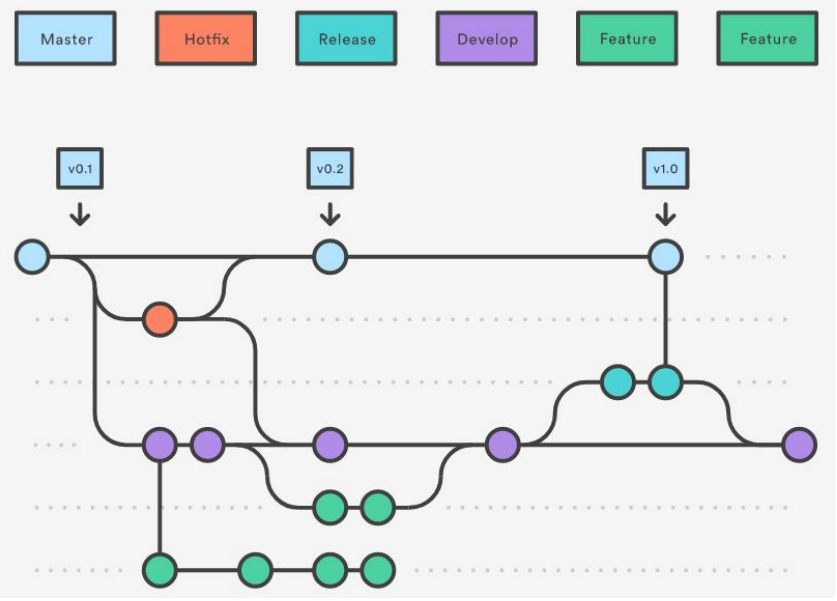
Figure 12 – Releases are forked from develop to master



Source: Atlassian Bitbucket, 2020.

The only acceptable way for a branch to merge directly into master is in the case of bugfix. This case is called hotfix, and can be seen on Figure 13.

Figure 13 – Hotfix can be merged directly to master



Source: Atlassian Bitbucket, 2020.

If the bug is discovered before going to production, then it would be only a bugfix, and must be merged to develop the same way as other features.

5.2.3 Agile Methodologies

As seen in the previous section, this project uses Git for both version control and code repository. For all the rest — planning what would be implemented and how, who would work in which task, what would be done in every working cycle and so — the Agile Methodologies were used.

The Agile Manifesto preys that people and their interactions are worth more than processes and tools, because although processes and tools are obviously important, software development is a human activity, and the developers' interactions are highly linked to quality. Another aspect of the Agile Manifesto that was incorporated to this project is that a working application is worth more than a vast documentation (AGILE MANIFESTO, 2001). And the last factor that concerns this project is that to respond to changes is more important than to be attached by a plan.

Of course, due to the size of the team and the scale of the project, not every aspect of these Agile Methodologies was applied, but some of them were. Some aspects of Scrum (SHUTERLAND, 2019), one of the most famous Agile methodologies, that were applied can be seen in the list below.

a) The working cycles were planned for a timebox of two weeks (Sprint);
b) The features to be implemented were mapped and putted on a backlog list;
c) There wasn't an official Product Owner, so the priorities of tasks to be done were discussed with Professor Begoña and between the team (Sprint Planning);
d) At the end of every cycle a meeting with Professor Begoña was done in order to present the work of that cycle (Sprint Review).

In order to organize all the tasks to be done in every Sprint, a Kanban was created on Trello's website, with the following columns: backlog, to do, doing, review, test, done. The features that were decided to be implemented were cracked in smaller tasks, because by doing this, they usually were implemented faster, and the code review and test was easier for the other person. In the "to do" column was put only the tasks to be done in that working cycle (in this case, in two weeks). Every time a developer would take a task to do, would put it on the "doing" column. By doing this, the other person on the team would know in which task she would be

working. After finishing a task, the developer would move the task from “doing” to the “review” column on the Kanban, and at the same time, would open a Pull Request on Git (in order to be able to merge the working branch to develop, as seen in the previous section of this chapter). After the code review was approved, the other person would finally test it. If everything worked alright in this flow, the task would be closed and put on the “done” column.

5.2.4 Database

For this project, it was chosen MongoDB, a NoSQL (Not Only SQL) database, which proposes to manage a big volume of data (Big Data), semi structured or not structured at all, and which provides high availability and scalability (LÓSCIO, 2020).

A NoSQL database was chosen instead of a SQL one because of the type of data this project demands. The goal of this database is to store users’ symptoms, which are gathered through a form, and which are constantly changing along with scientific research, and so as the data’s structure. And also, because this project was designed to scale, and so, it could attend a large number of users.

Thus, the following appointments were considered for this choice:

a) The structured of data itself;
b) The speed of search and insertion on database;
c) The simplicity to create and maintain the database.

Currently, there are lots of NoSQL databases on the market, such as: Cassandra, Hypertable, MongoDB, Redis, CouchDB and Dynamo. And there are different types of data models, in which the mostly known are: key-value, column-oriented, document-oriented and graph-oriented.

One of the reasons to choose MongoDB is because it’s document oriented, and so it can store document collections, being a document an object with a unique identity and a set of fields — in which, there is not a rigid schema as happens in SQL databases (LÓSCIO, 2020). Thus, the document’s structure can be updated, with new fields, without major problems.

5.2.5 Mobile programming language

For the mobile development of this project it was chosen the Flutter framework. It's an open source project created by Google, using Dart language, with the goal to be multiplatform, focusing on building interfaces. That is, to build a performatic app and also with a high-quality graphic interface.

Flutter enables the development for both Android and iOS from a single source code. Since them both are the most known and used operating systems for smartphones, it's a very positive thing, because the alternative would be to develop a native code for Android, and another one for iOS (BASSETO, 2019). That would demand for the developers to have the knowledge of two different technologies and also would increase the time spent with the development, beyond complicating the updates of the application, because the developers would have to change the features in two different codes.

Flutter has as a concept the componentization, breaking the resources into separate reusable packages, in which every component is a widget. The positive side is there are lots of stylish and useful components ready to be used, and it's very easy to personalize them and to create new ones. Some known applications that use Flutter or have migrated to it are: Nubank, Philips Hue, Ebay, Groupon and other (FLUTTER, 2020).

Besides the advantages written above, Flutter also has:

a) Facility to use native resources — it just needs to setup the libraries and it's ready to use;
b) A detailed and comprehensive documentation;
c) Hot Reload, meaning the changes in code are reflected on smartphone or on the emulator almost instantaneously. This implies a higher performance of coding.

Due to all positive appointments above, and the need to develop all features quickly, and aiming for a friendly graphic interface as Material UI, the Flutter has proven to be a great choice for the application's development.

5.2.6 Server programming language

NodeJS was created at the end of 2009 by Ryan Dahl and 14 more developers. It’s a popular platform to build server-side applications on JavaScript, and it runs on JavaScript Engine V8 from Google (NODEJS, 2020), which was first designed for Chrome web browser.

One of the most important differences between NodeJS and other technologies for web, such as Python, Ruby and Java, is it has a non-blocking thread architecture, allowing a high performance and low memory cost. This kind of thread aims to use completely and in an efficient way the whole process capacity of servers, giving a better time response after a request (PEREIRA, 2014).

Other characteristics of NodeJS are: to be single-thread, to be event driven and to be highly scalable. From NPM (Node Package Manager) it's allowed to compose a huge module set and external packages from the developers’ community, who provide them for free, so developers can reuse third-party codes in a practical way (PEREIRA, 2014).

6 DESIGN

Based on the current state of the art, how would the perfect mobile application look like? What features would it have?

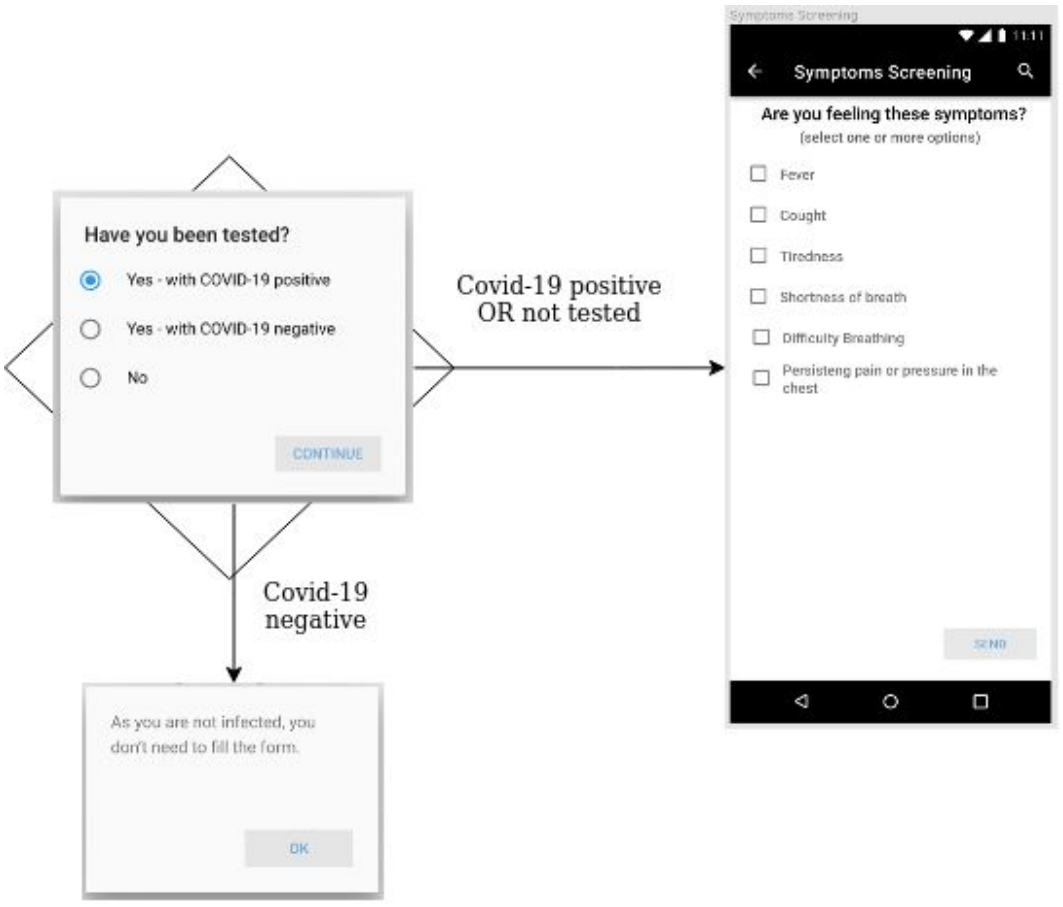
6.1 SYMPTOMS SCREENING

The application should use a form, a kind of a checklist, with the most common symptoms of COVID-19, so the user could fill it. Although more than half of the infected don't present any symptom, or only present mild ones, this feature could help improve COVID-19 diagnosis. It’s important to notice that this feature should also ask the user if he/she got tested for COVID-19 and the result of it.

With this, it would be easier to track who was tested; how many were tested positive and don’t present any symptom; and the most common symptoms. When this form is sent to a server, it could add a timestamp as well, so it could be developed in another feature, a dashboard with a timeline of symptoms, in order to improve our understanding of how the clinical frame develops through time.

The Figure 14 presents a first version of the design of this Symptoms screening and the dialog screens that is shown first to the user.

Figure 14 – Symptoms-screening screen



Source: Designed by the author using Figma.

6.2 POPULATION MOBILITY

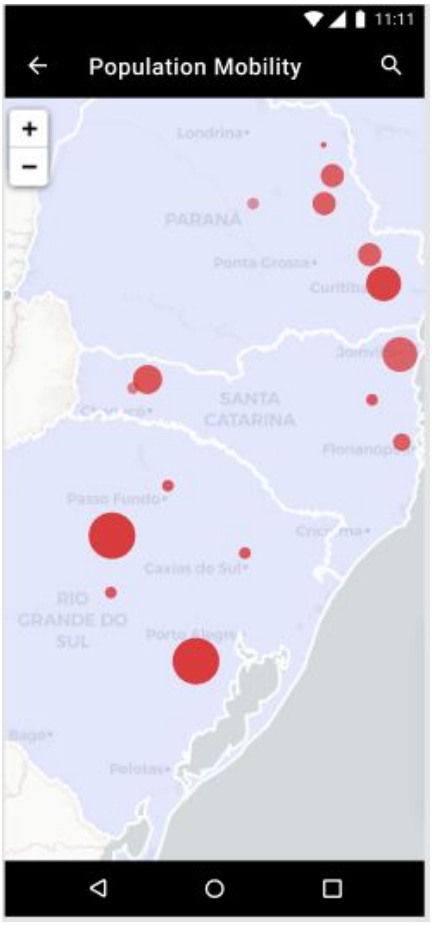
This feature intends to track people's mobility in order to discover the social isolation rate (so the governments can see if it's working and take actions based on it), or in most serious cases (when it's already implemented shutdowns and lockdowns in a particular community or region) if the population is respecting it.

The data could be gathered in two different ways. The first would be anonymous, in a partnership with telephone and internet companies, and the result would be about the population as a whole and not about individuals. And the second option is the application could request the user to share his/her location, and people who stay home and respect the social isolation could share it on social media and so on.

In some regions of Brazil, an application like these (with anonymous data) is already being used by policy forces and public agents (GOVERNO DE SANTA CATARINA, 2020).

For this feature, we have thought of a design like the one seen in Figure 15, with a map showing the density of people accordingly with the balls' sizes. In the search bar, the user could seek for the population mobility in other places as well.

Figure 15 – Population mobility screen



Source: Designed by the author using Figma.

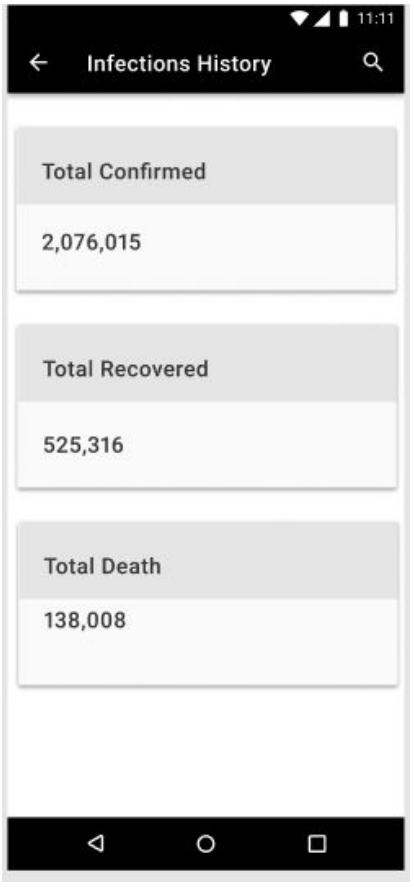
6.3 INFECTIONS HISTORY

This feature intends to present official data from respected universities, research centers and governmental sites, so the user can stay well informed about COVID-19's rates: how many people are infected, how many are already recovered, and how many have died. This feature is probably one of the most important ones,

because accurate data is really important to understand the pandemic, its growth, which actions did work and which didn’t.

Besides, it's important for the user to be able to seek information (through a search bar or something similar) about other regions so he/she can compare the results from different public and governmental actions. For this feature, something like Figure 16 was thought, with the possibility to add the death rate of the disease and a linear and logarithmic graphic about the disease’s growth in the world as in particular regions.

Figure 16 – Infections history screen



Source: Designed by the author using Figma.

6.4 INFECTED PEOPLE NEARBY

This feature shows if there are infected people near the user or near the user’s home. A version of this feature has been used in a system implemented in Santa Catarina, south of Brazil, by its government. The healthcare system owns information about who got tested to COVID-19 and their results. Then, the

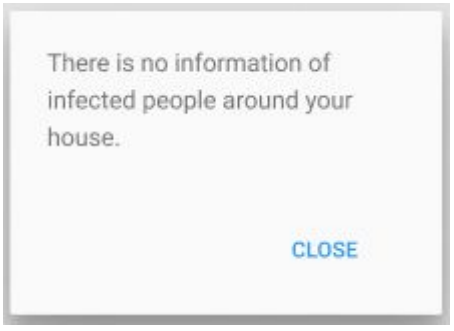
government sends text messages to people living within 400 meters of the infected, so they can stay safe (PREFEITURA DE FLORIANÓPOLIS, 2020).

Another version of this feature could be by people sending (via Bluetooth or by internet connection) the information to the neighbors or when the user goes out on the streets, so it could serve as a “free pass” to go out on the streets and to make sure everyone around you (when on a market or something) are healthy.

Of course, there are both ethical and practical obstacles to implementing it, besides a false sensation of safety when you don’t receive any of these messages. After all, are your neighbors really healthy or they didn’t get tested?

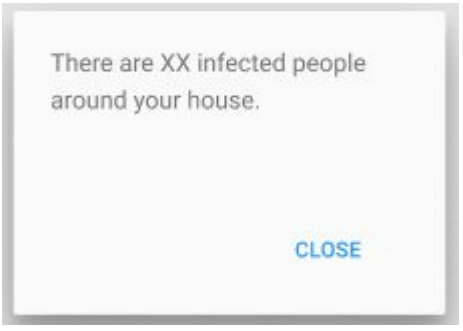
A design of a screen showing there are no infected people nearby can be seen in Figure 17 and with XX infected people nearby can be seen on Figure 18, where XX is the number of ills.

Figure 17 – Infected people nearby when there are none



Source: Designed by the author using Figma.

Figure 18 – Infected people nearby when there are XX ills



Source: Designed by the author using Figma.

6.5 HEALTH SYSTEM CAPACITY

This feature presents the hospitals’ capacity in a given region and crosses this information with how many people are already hospitalized in infirmaries and in intensive care units. Of course, the optimal solution to gather the data would be if the government provides this information (for both public and private hospitals) through API’s or websites for the concerned audience. In the Age of Information, this kind of data should be open. But, as we don’t have this on a global scale yet, this feature could be implemented in a partnership with hospitals and governments so they could share it on an application.

As the “Infections History” feature, this one could be used in order to evaluate how effective the public actions are, if the government should declare a lockdown or let the people go out, how healthy is the healthcare system, if it’s going to be overburdened and so. A design of this screen can be seen on Figure 19.

Figure 19 – Health system capacity screen

Source: Designed by the author using Figma.

6.6 GOOD NEIGHBORHOOD NETWORK

More than a feature, this one would be a whole different application. It intends to create a network system where people offer to buy food, medications and other essential supplies for the elderly, the ill, the disabled or anyone who can’t leave their houses (like the people who got infected by COVID-19 and live alone, so they can’t go outside because of sanitary reasons).

This application would have two kinds of users: the needies and the shoppers/providers. Both of the users would create an account, where they would set which kind of user they are. Then, every time the needies would need something, they would fill a form with their needs and location. The shoppers/providers would register in which region they could go shopping and deliver the items. And then, it would need to have a match between these two kinds of users.

This service could be provided for free or could involve a small price to be done.

6.7 NEWS CHANNEL

This feature aims to present statistics and news from news agencies or governments, in order to avoid fake news spread. In times where people often get informed by social media applications, it's important to appreciate again the value of a free and quality press, made by professional journalists. Journalists usually investigate the topics they write about (especially in crisis like the COVID-19 one) and they do have a duty to share verified data. And besides, they often do a curation of the most important topics of the day.

Of course, a feature like this would only make sense if the user could filter the news for his/her region. Although it's important to know how the rest of the world is doing with the pandemics, it's probably more needed to know about one's own region.

The design of this feature can be seen on Figure 20.

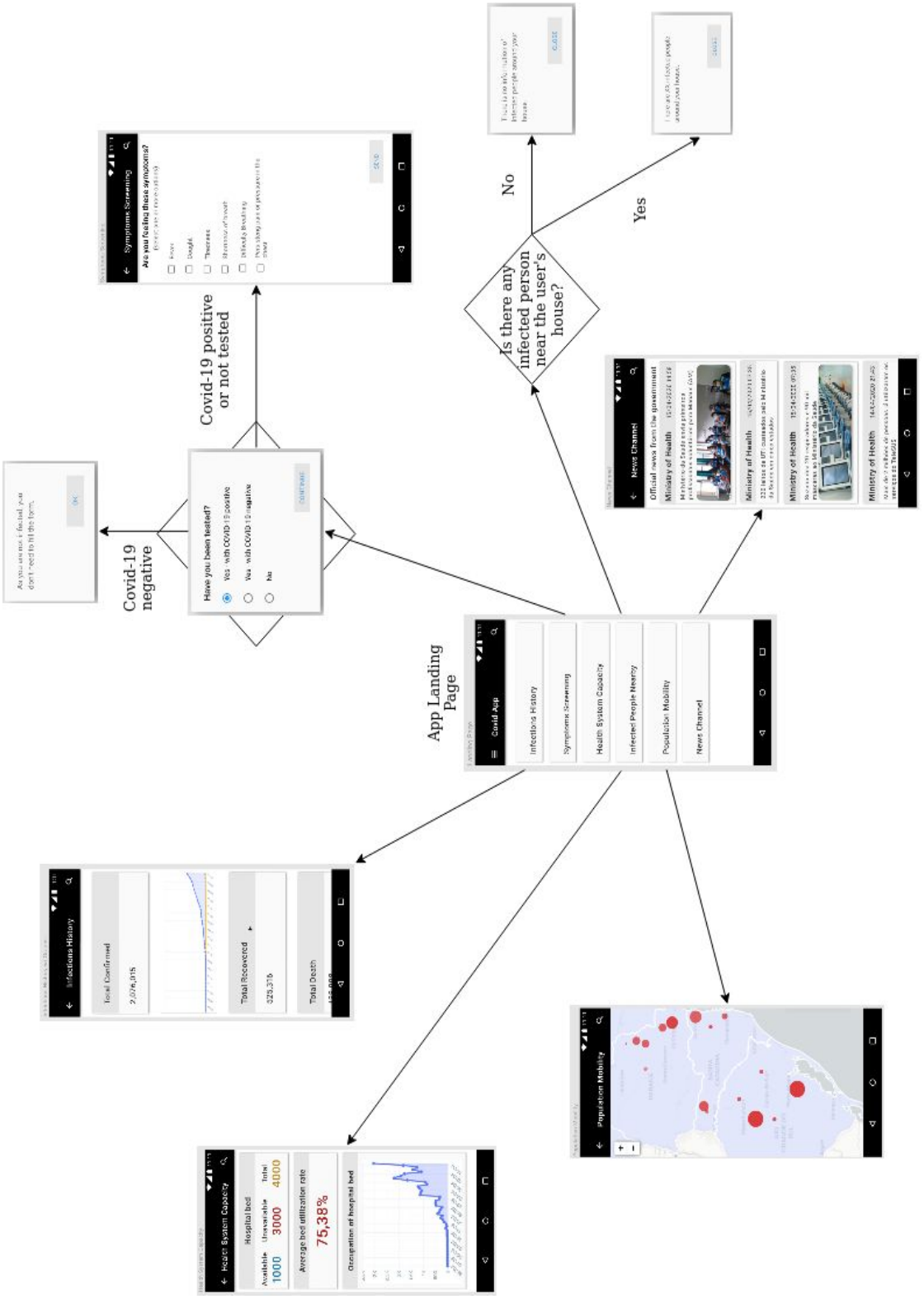
Figure 20 – News channel screen

Source: Designed by the author using Figma.

6.8 DESIGN DIAGRAM

A design of all of these features can be seen on Figure 21 combined. For some of them a flow is needed to show the correct screens to the users accordingly with their profile.

Figure 21 – All diagrams combined



Source: Designed by the author using Figma.

7 DEVELOPMENT

As written in the Methodology chapter, this project had seven steps, with the development starting on the third.

7.1 VERSION CONTROL

Before really starting to code, at first, it was created a GitHub repository for working in a Git Flow version control system (as written in chapter 6), with 2 main branches: master and develop.

All of the branches were created based on the develop one (which was always the most updated branch), and then, after some feature was finished, a Pull Request was opened answering three questions:

a) What's the goal of this pull request?
b) What was done to achieve this goal?
c) How to test if it really works?

Besides these, when creating a User Interface (UI), images of it were posted on the Pull Request as well. Before merging the branch into develop, it was done both a code review and tests. The code review aimed not only to look for errors, but also to look if the code was clean. Only after the code reviews and tests approval, the working branch was merged into develop. And the develop branch was merged into master before every meeting with the stakeholder — which in this case was Professor Begoña — in order to show the last reliable and functional code.

Added to the Flutter Application, there is also a server running on the project (as described on the Methodology chapter).

7.2 FLUTTER APPLICATION ARCHITECTURE

After choosing the language (Dart/Flutter), whose reasons can be seen on the Methodology chapter, and creating the repository, one of the main concerns was to build a project that could scale. When creating a Flutter project, there are 4 mandatory directories and three files as shown in Figure 22.

Figure 22 – Screenshot of a basic Flutter project

Source: Screenshot of the project architecture.

As previously said, Flutter suits both Android and iOS mobile systems, so in these directories, the developer must specify special requirements, authorizations and so. As the scope of this project only contemplates Android, the only change made was in order to authorize the application to use the users' internet connection and configurations in order to put it on Play Store for the Alpha tests. Build directory contains all the rules to configure both debug and release versions, and its particularities.

Pubspeck.yaml is where must be defined dependencies on external libraries and also the assets of the project. Because this project is part of an Exchange Internship, one of the libraries used was Intl, to help manage for internationalization. Every text that's shown in the application was settled on a String variable, and although the first version of the app is entirely in English, a file to translate it to Portuguese and Spanish were already created.

The main.dart is where the application runs and calls for every other method. The entire application must be settled inside the lib directory, and regarding best practice of software design and architecture, the lib directory's organization can be seen in Figure 23.

Figure 23 – Screenshot of the basic architecture of this project

Source: Screenshot of the project architecture.

Inside the lib directory, the API directory contains methods for connecting both to external APIs (as better explained in section 8.3) and the server created in this project (shown at section 8.5). The screens directory contains all the screens, the static contains the translation files, the routes to every screen, and theme concerns, in other words, the static files. And finally, as Dart/Flutter is an Object-Oriented Programming Language (or even, a Widget Oriented Language, as explained in chapter 6), all the objects are described in files on models directory, and the widgets for reuse purposes (dictated by clean code practices) are stored on widgets directory.

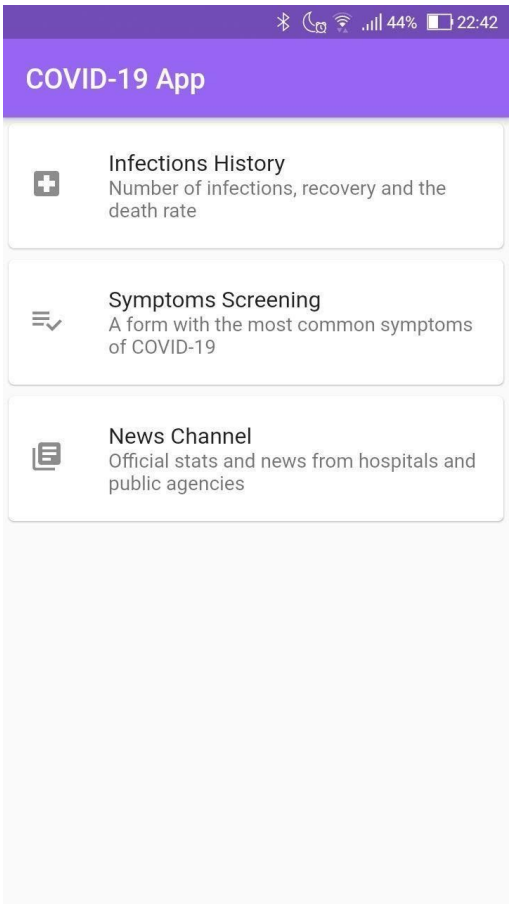
7.3 FLUTTER APPLICATION FEATURES

From all the features designed in chapter 7, only three were chosen for this first version of the application, especially because of technical concerns, but also because of the duration of this project.

7.3.1 Landing Page

The landing page (configured on main.dart file, as explained on section 8.2) of the application, which can be seen on Figure 24, has three cards that lead the users to the implemented features. Each card has a title and an explanation of what that feature does.

Figure 24 – Screenshot of the Landing Page of the application

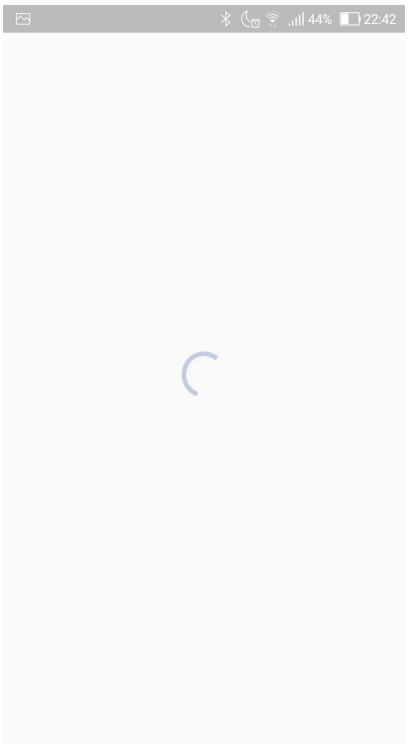


Source: Screenshot of the app.

7.3.2 Check for internet connection

All screens on the app depend on internet connection. Because of this, when the user tries to enter every screen, at first, it checks if he/she is already connected. The method that checks for connectivity is on file lib/api/connectivity.dart. While it's checking, a spinner appears on screen as can be seen on Figure 25.

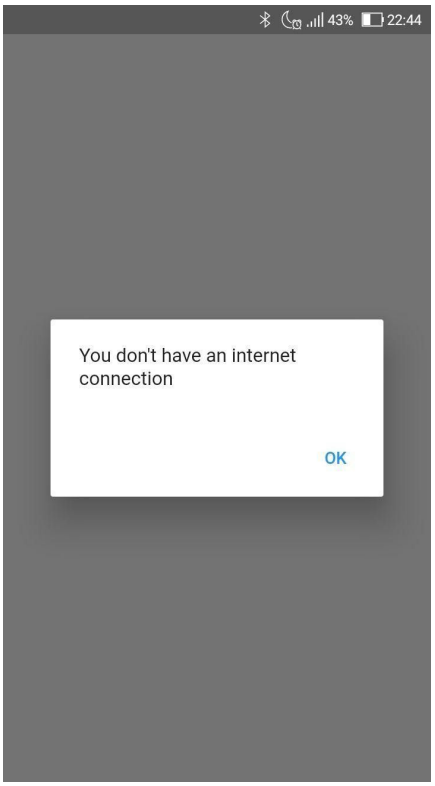
Figure 25 – Screenshot showing spinner while the application checks for connectivity



Source: Screenshot of the app.

If the user isn't connected on the internet, a dialog is shown as seen on Figure 26. If he/she is connected, the page is loaded as shown on next sections.

Figure 26 – Screenshot showing dialog when the user isn’t connected on the internet

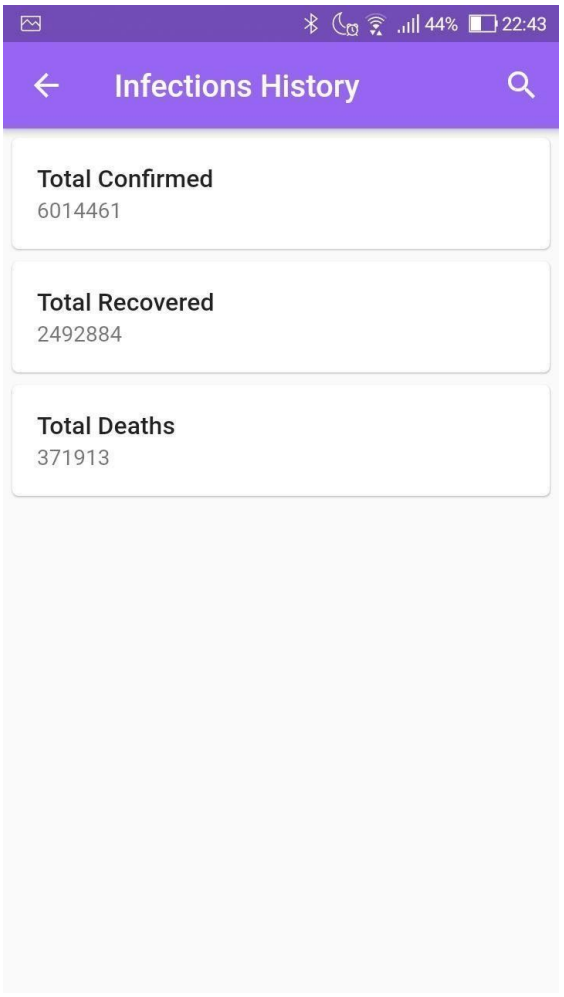


Source: Screenshot of the app.

7.3.3 Infections History

On the Infections History screen is shown the total number of infections, recoveries and deaths from the world, as seen in Figure 27. All the information of this screen, as well as the subsequent when the user filters by country, are gathered from John Hopkins, as better explained on section 8.4.

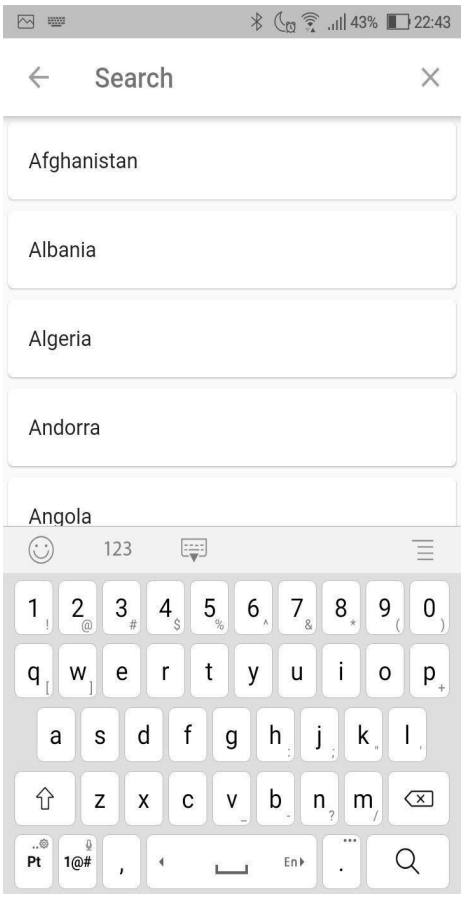
Figure 27 – Screenshot of Infections History screen



Source: Screenshot of the app.

As can be seen on Figure 27, there is a search bar next to the title (Infections History). When the user clicks on it, a list of all countries can be seen as in Figure 28.

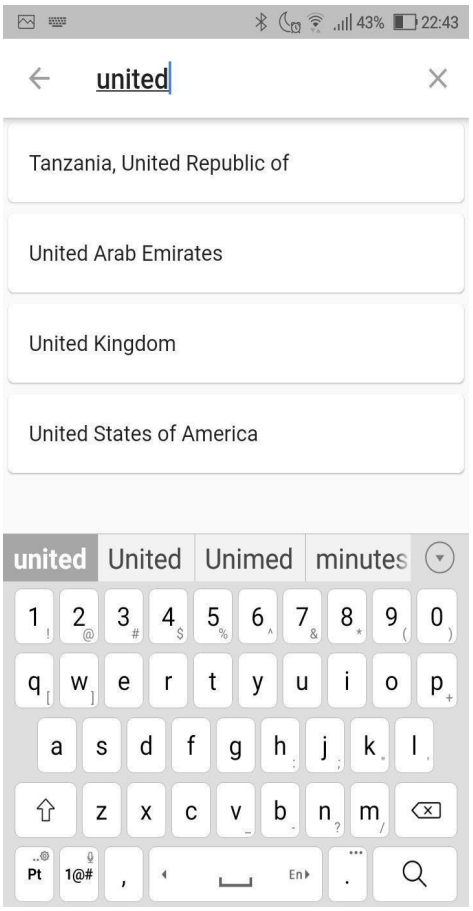
Figure 28 – Screenshot when user wants to filter Infections History by country



Source: Screenshot of the app.

One thing that is important to notice, is that the filter starts its function when the user starts typing, and not only when he/she finishes it, as can be seen on Figure 29.

Figure 29 – Screenshot showing the filter working since the user starts typing

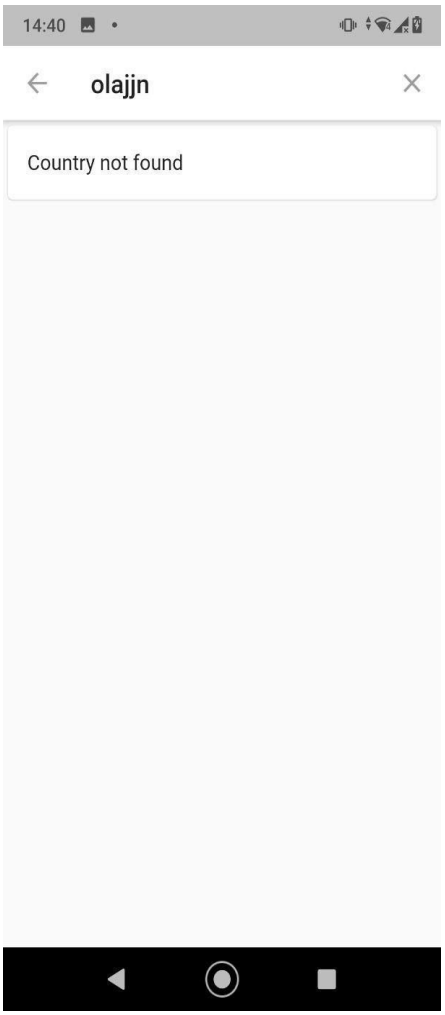


Source: Screenshot of the app.

Another aspect of the search that can be seen is that the user doesn't need to write the countries in capital letters, it works regardless of upper or lower cases.

When the country can be found, an error message is shown, as shown in Figure 30.

Figure 30 – Screenshot showing the country can’t be found

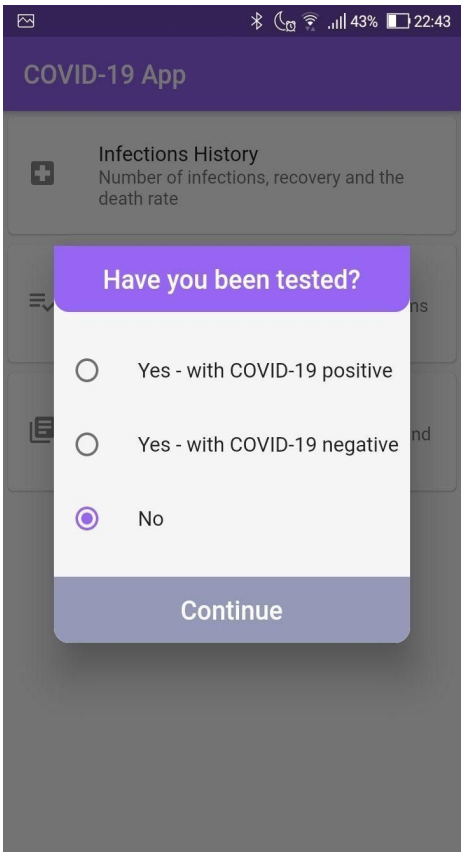


Source: Screenshot of the app.

7.3.4 Symptoms Screening

When the user clicks on Symptoms Screening card, at first appears a dialog asking if he/she has been tested for COVID-19 and the result. This dialog can be seen on Figure 31.

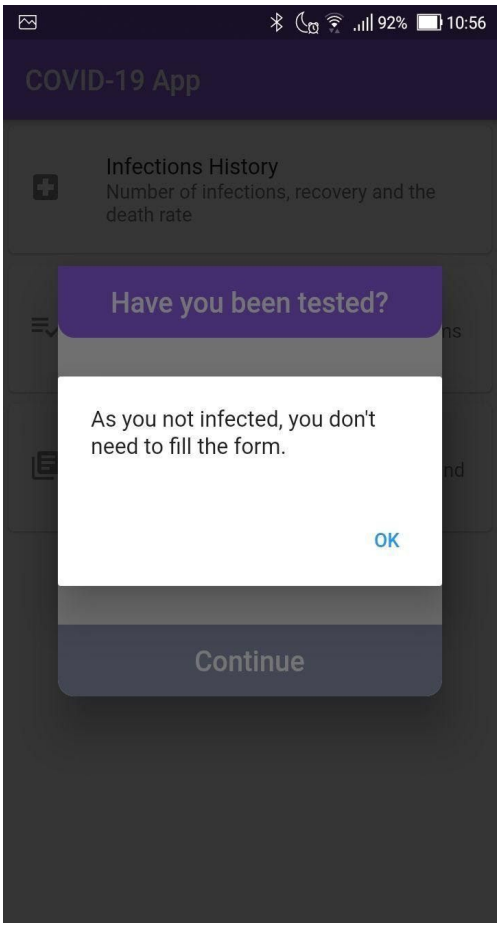
Figure 31 – Screenshot of dialog when user clicks on Symptoms Screening



Source: Screenshot of the app.

If the user got tested and the result was negative, there is no reason for screening his/her symptoms. So, appears on the screen a dialog as in Figure 32.

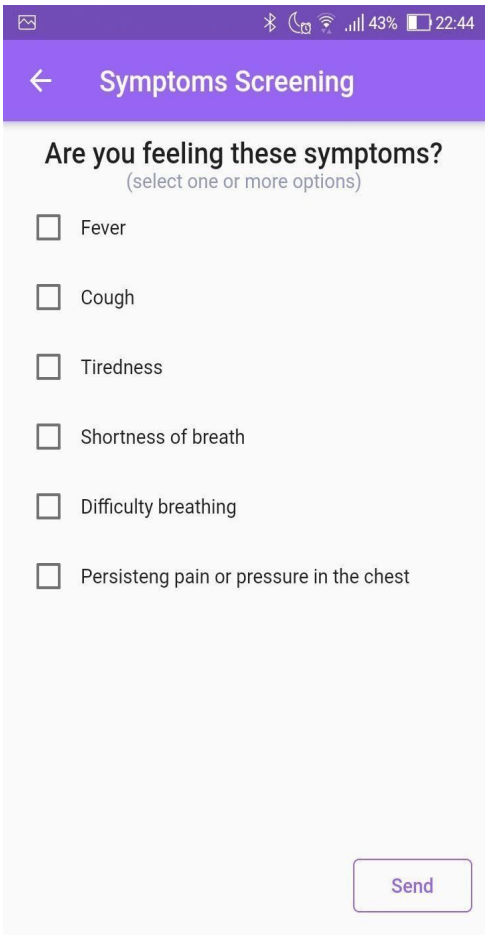
Figure 32 – Screenshot when the user got tested and is not infected



Source: Screenshot of the app.

If in the first dialog (shown at Figure 31) the user says he/she didn't get tested or got tested positive for COVID-19, a Symptoms Screening screen is shown, as can be seen on Figure 33.

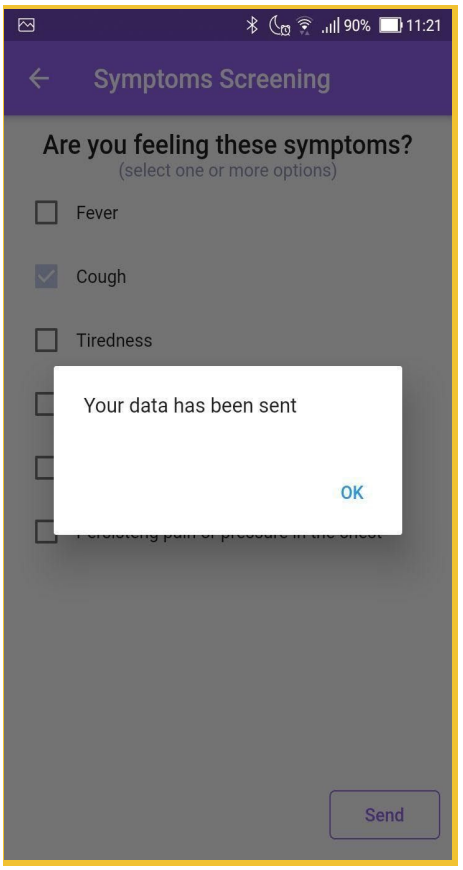
Figure 33 – Screenshot of Symptoms Screening screen



Source: Screenshot of the app.

And finally, when the user sends the symptoms to the server, a dialog appears if it was successful, as shown in Figure 34.

Figure 34 – Screenshot when the user sends symptoms to server

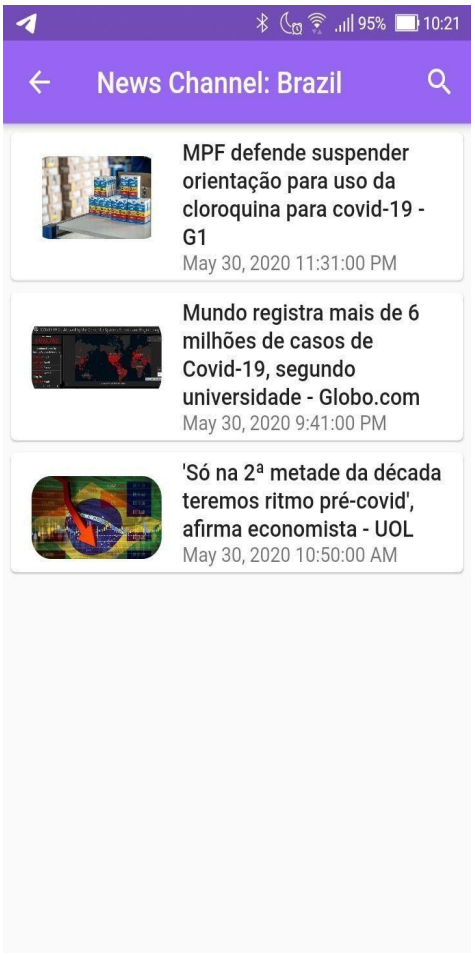


Source: Screenshot of the app.

7.3.5 News Channel

The landing page of News Channel shows news from Brazil, as can be seen on Figure 35, but when the user clicks on the search bar it works similarly to the Infections History, where he/she can filter by country.

Figure 35 – Screenshot showing the filter working since the user starts typing



Source: Screenshot of the app.

7.4 COMMUNICATION WITH EXTERNAL APIS

There are basically two external APIs on this project, and the code to connect to them both are in lib/api/ directory. For the data shown in Infections History, the application connects to “Coronavirus COVID19 API” created by Kyle Redelinghuys. This API is an open source project, with an official website (REDELINGHUYS, 2020) and a public repository (GITHUB, 2020). This API gathers all data from John Hopkins Center for Systems Science and Engineering.

The other external API used in this project is to populate data on the News Channel screen. For this purpose, it’s used the News API, created by Google (NEWSAPI, 2020).

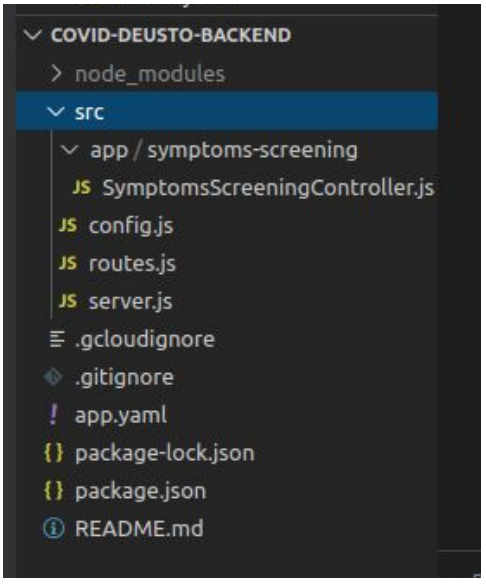
The main difference between them is that the News API by Google needs an authentication token, and the “Coronavirus COVID19 API” doesn’t. But the type of data consumed in both is the same: JSON (JavaScript Object Notation).

7.5 SERVER CREATION

As explained in the Methodology chapter, the server-side of this project was developed in NodeJS with a NoSQL database (MongoDB), and the following libraries/packages were used from NPM (NodeJS Package Module): (i) express and (ii) body-parser.

The server was created aiming to receive symptoms screening data from users, and then, send them to MongoDB Atlas in order to save it (MONGODB, 2020). The server is hosted in Google App Engine, and all the data is available online (COVID-APP-DEUSTO, 2020). In Figure 36 can be seen an image with the server’s structure.

Figure 36 – Screenshot of the basic architecture of the server



Source: Screenshot of the project architecture.

A brief explanation about the main functionalities of the server can be seen below:

a) server.js: responsible for server’s initialization and configuration (the server’s port and MongoDB’s access);

b) routes.js: contains all the routes, the HTTP method to access them and the controller responsible to process requests;
c) SymptomsScreeningController.js: responsible for data acquisition, to connect the server to the database and the CRUD operations (to create, read, update and delete) on database.

7.6 COMMUNICATION BETWEEN APP AND SERVER

As written in the previous section, the server side contains an API where the application can post, through a JSON object, the user's data. Until now, everyone can access that endpoint (to both create and read data) without any kind of authentication or authorization. One of the features that should be implemented in the Conclusions and Future Lines chapter is to create an authentication where the user can view only his/her own data.

8 RESULTS

After finishing the first version of the application, it was released for a close group of testers, among them two UX/UI designers and one software developer and systems analyst. Then, some of their suggestions were implemented, and the version 1.1 was released for new tests, this time for more than 30 users, whom have applied two different surveys. The first tests are described in section 8.1, and the second (and larger tests) are described in section 8.2 of this chapter.

In both tests sets the main concern was about usability. Usability refers to the following items (MARCUS, 2020):

a) Intuitive design;
b) Easy of learning;
c) Efficiency of use;
d) Memorability;
e) Error frequency or severity;
f) Subjective satisfaction.

8.1 ALPHA TESTS

As written above, at this point, there were three testers:

a) Luiza Berté de Almeida e Silva, UX/UI designer at SAP SE (Systems, Applications and Products in Data Processing), allocated at Stuttgart, Germany;
b) Bárbara Laura Cidral, UX/UI designer at CERTI Foundation and researcher at UDESC (Santa Catarina State University), Brazil;
c) Mateus Moraes Bueno, Information Technology Coordinator at IFC-Blumenau, Brazil.

8.1.1 Feedback of a UX/UI designer

One of the feedbacks was given by Luiza Berté de Almeida e Silva, on May 30th 2020:

> “First of all, I’ve found the topic very relevant and also found it cool to be able to search by country! Then, I started the interaction clicking on the Infections History button, and the content is shown in shadow cards, which was supposed to be clickable, but was not — and there was no feedback about it. So, when I’ve clicked on the magnifying glass [the search bar], I’ve found the functionality nice, but also too generical, because it doesn’t explain to me what I can search. I would suggest changing the title to Search Country, or something similar, just to be clearer.
> About the Symptoms Screening: I’ve also liked the proposal because it can bring the user more comfort in understanding if there is a possibility of being infected with Corona, but actually, after I sent my data, the application didn’t return any feedback at all, so I felt an emptiness. About this, I’d suggest an introduction to what this functionality represents and what kind of answer the user can get. Another aspect that I didn’t find very consistent in this feature was the fact that the first question of it is a popup and then it becomes a new page, but it’s just a detail.
> About the News Channel screen: I found it very cool that the information can be filtered by country. Very cool indeed. But again, I got confused about the expectation with the search bar and its real function. I have found it would allow me to make other kinds of searches. Maybe it should show somehow that the filter is by country only, and the user has no liberty concerned with the subject of the search.
> And that’s it. The idea of the app is really cool and my feedback is related to UX and UI aspects.” (SILVA, 2020)

8.1.2 Satisfaction Survey

Besides the conversation with Luiza Berté, written above, it was created an online survey divided in 3 major topics: the functionalities, the design and (eventual) bugs or suggestions in general. The closed questions followed a Likert Scale, with great, good and bad as options, and beyond them there were also some open questions, totaling 13 questions. All of them can be seen below with the users' responses.

Between May 30th and June 7th, 2020, the testers cited at the beginning of this section have answered the following survey.

In terms of functionality, the closed questions can be seen on Table 2. The Good option means “good — with some aspects to be improved” and the Great option, in this case, means “I can understand what this is about”.

Table 2 – Closed questions on survey about functionality

Question	**Bad**	**Good**	**Great**
What did you think about the landing page?		66,7%	33,3%
What did you think about the Infections History screen?		100%	
What did you think about the Symptoms Screening screen?		100%	
What did you think about the News Channel screen?		66,7%	33,3%
In general, what did you think about the functionalities of the application?		66,7%	33,3%

Source: Questions created by the author.

In this section of the survey, there was an open question as follows: “As to the features, do you have any suggestions?” With two answers:

> “I believe the numbers in Infections History aren’t available to all publics, in terms of inclusion (they have a small size and should be bigger). Maybe in the Symptoms Screening a more diversity of symptoms can be included. And I missed more news on the News Channel and didn’t understand quite well the search functionality on this screen.” (CIDRAL, 2020).

“You should bring more visual features, with graphics and figures that exemplify the symptoms. The landing page should be more attractive too, maybe a newsfeed and action buttons to the symptoms screening and infections history.” (BUENO, 2020)

In terms of design, the closed questions can be seen on Table 3.

Table 3 – Closed questions on survey about design

Question	**Bad**	**Good**	**Great**
What did you think about the presentation of the application?		100%	
What did you think about the colors of the application?	33,3%	33,3%	33,3%
What did you think about the font used on the application?		50%	50% (*)
What did you think about the messages on the application, for example, when you try to use some feature without internet connection?		50%	50% (*)

Source: Questions created by the author.

* Some questions have 50:50 distribution of answers, while others have 33:33:33 because the question about colors was added later.

In this section of the survey, there was an open question as follows: “As to the design of the application, do you have any suggestions?” With two answers:

> “Some deliberations about the design were made in the last item. The color didn’t relate well with the theme, but also didn’t harm the use. I believe that a better application of a hierarchy of fonts would help the elderly public or the public with vision comorbidities. Another issue is about the punctuation. If no result is found in the searches, the following sentence is shown: “Country not found!”. There is no necessity to use the exclamation mark, because in other items there is no mark, so it’s inconsistent. Another issue is that the app takes a while to fetch the data, but this doesn’t stop the use. The app functions well on the landscape position, except for the Symptoms Screening screen, because you can’t flow the screen and click on submit. Another issue is that it erroneously warns the data was sent, even when there is no internet connection. In News Channel and in Infections History it correctly warns about this state of internet connection.” (CIDRAL, 2020)

While Bueno have said: “More icons, graphics and figures in every screen” (2020).

In terms of bugs, the closed questions can be seen on Table 4.

Table 4 – Closed questions on survey about bugs

Question	**Yes**	**No**
Did you find any bugs in the application?		100%

Source: Questions created by the author.

And finally, there was one more field for suggestions: “Do you have any more suggestions that don't fit in the previous questions?” with one answer:

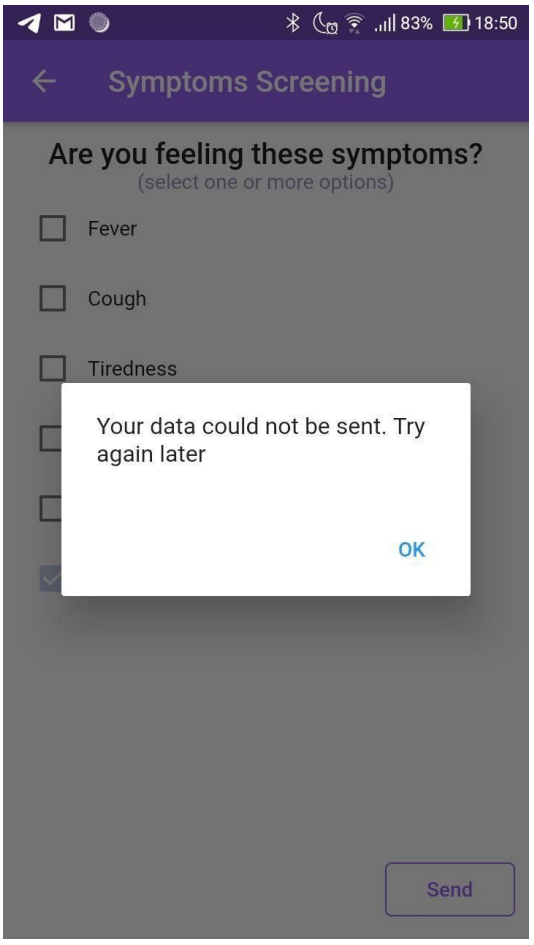
“New features with the historicity of every country and a parallel between the curves would be interesting. But the app fulfills its role.”

8.1.3 Implemented Suggestions

Although all given suggestions were valid, due to a time limitation only a few were implemented, creating with this a version 1.1 of the application. They can be seen in the list below.

a) The application should work only in the portrait mode;
b) The internet connection should be checked before entering on the Symptoms Screening screen;
c) The return status should be checked after sending data to the server. If it didn’t succeed, there should be a message to the user, as shown in Figure 37.

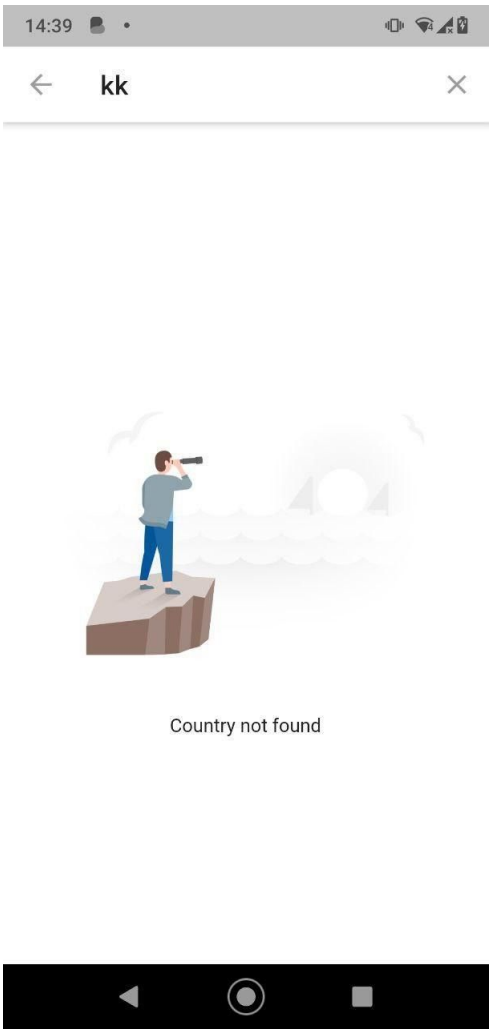
Figure 37 – Message shown when an error occurred sending the data to server



Source: Designed by the author.

d) The search screens (both in Infections History and in News Channel), when a country isn't found, should change the error message, as shown in Figure 38.

Figure 38 – Screenshot with new message when country isn't found



Source: Designed by the author.

8.2 USERS' TRIALS

After the first suggestions were implemented, a version 1.1 was released to a group with more than 30 users, mainly students of Systems Analysis and Development and students of Information Technology Management at the Federal Institute of Santa Catarina, Brazil. All data were collected between June 16th and June 23rd, 2020.

8.2.1 USE Questionnarie

This survey intends to measure usability focusing in four points: usefulness, ease of use, ease of learning and satisfaction. In order to apply this survey, it was created a Google Forms, in which 32 users of the version 1.1 have it.

All the answers vary in a scale between 1 (totally disagree) and 7 (totally agree). There is also a NA (doesn't apply) option. The answers can be seen on Table 5.

Table 5 – USE Questionnarie

Usefulness	
It helps me be more effective.	1: 2: 3: 4: 4/32 = 12.5% 5: 3/32 = 9.375% 6: 5/32 = 15,625% 7: 14/32 = 43.75% NA: 6/32 = 18.75%
It helps me be more productive.	1: 2: 3: 1/32 = 3.125% 4: 2/32 = 6.25% 5: 3/32= 9.375% 6: 8/32 = 25% 7: 10/32 = 31.25% NA: 8/32 = 25%
It is useful.	1: 2: 3: 4: 5: 3/32= 9.375% 6: 8/32 = 25% 7: 21/32 = 65.625% NA:

It gives me more control over the activities in my life.	1: 1/32 = 3.125% 2: 3: 2/32 = 6.25% 4: 3/32= 9.375% 5: 4/32 = 12.5% 6: 9/32 = 28.125% 7: 7/32 = 21.875% NA: 6/32 = 18.75%
It makes the things I want to accomplish easier to get done.	1: 1/32 = 3.125% 2: 2/32 = 6.25% 3: 1/32 = 3.125% 4: 3/32 = 9.375% 5: 1/32 = 3.125% 6: 8/32 = 25% 7: 10/32 = 31.25% NA: 6/32 = 18.75%
It saves me time when I use it.	1: 2: 3: 4: 5: 3/32 = 9.375% 6: 16/32 = 50% 7: 11/32 = 34.375% NA: 2/32 = 6.25%
It meets my needs.	1: 2: 3: 1/32 = 3.125% 4: 1/32 = 3.125% 5: 7/32 = 21.875% 6: 14/32 = 43.75% 7: 8/32 = 25% NA: 1/32 = 3.125%
It does everything I would expect it to do.	1:

	2: 1/32 = 3.125% 3: 1/32 = 3.125% 4: 2/32 = 6.25% 5: 4/32 = 12.5% 6: 10/32 = 31.25% 7: 12/32 = 37.5% NA: 2/32 = 6.25%
Ease of Use	
It is easy to use.	1: 2: 3: 4: 5: 6: 11/32 = 34.375% 7: 21/32 = 65.625% NA:
It is simple to use.	1: 2: 3: 4: 5: 1/32 = 3.125% 6: 8/32 = 25% 7: 23/32 = 71.875% NA:
It is user friendly.	1: 2: 3: 4: 5: 3/32 = 9.375% 6: 11/32 = 34.375% 7: 17/32 = 53.125% NA: 1/32 = 3.125%

It requires the fewest steps possible to accomplish what I want to do with it.	1: 2: 3: 4: 5: 1/32 = 3.125% 6: 11/32 = 34.375% 7: 19/32 = 59.375% NA: 1/32 = 3.125%
It is flexible.	1: 2: 1/32 = 3.125% 3: 1/32 = 3.125% 4: 2/32 = 6.25% 5: 4/32 = 12.5% 6: 9/32 = 28.125% 7:12/32 = 37.5% NA: 3/32 = 9.375%
Using it is effortless.	1: 2: 3: 4: 5: 1/32 = 3.125% 6: 8/32 = 25% 7: 22/32 = 68.75% NA: 1/32 = 3.125%
I can use it without written instructions.	1: 2: 3: 4: 5: 2/32 = 6.25% 6: 5/32 = 15,625% 7: 24/32 = 75% NA: 1/32 = 3.125%

I don't notice any inconsistencies as I use it.	1: 2: 1/32 = 3.125% 3: 1/32 = 3.125% 4: 1/32 = 3.125% 5: 1/32 = 3.125% 6: 10/32 = 31.25% 7: 18/32 = 56.25% NA:
Both occasional and regular users would like it.	1: 2: 3: 4: 1/32 = 3.125% 5: 2/32 = 6.25% 6: 10/32 = 31.25% 7: 18/32 = 56.25% NA: 1/32 = 3.12%
I can recover from mistakes quickly and easily.	1: 2: 3: 4: 5: 4/32 = 12.5% 6: 11/32 = 34.375% 7: 15/32 = 46.875% NA: 2/32 = 6.25%
I can use it successfully every time.	1: 2: 3: 4: 1/32 = 3.125% 5: 1/32 = 3.125% 6: 10/32 = 31.25% 7:19/32 = 59.375% NA: 1/32 = 3.125%
Ease of Learning	

I learned to use it quickly.	1: 2: 3: 4: 5: 1/32 = 3.125% 6: 7/32 = 21.875% 7: 24/32 = 75% NA:
I easily remember how to use it.	1: 2: 3: 4: 5: 6: 9/32 = 28.125% 7: 23/32 = 71.875% NA:
It is easy to learn to use it.	1: 2: 3: 4: 5: 1/32 = 3.125% 6: 7/32 = 21.875% 7: 24/32 = 75% NA:
I quickly became skillful with it.	1: 2: 3: 1/32 = 3.125% 4: 5: 3/32 = 9.375% 6: 11/32 = 34.375% 7: 16/32 = 50% NA: 1/32 = 3.125%
Satisfaction	

I am satisfied with it.	1: 2: 3: 1/32 = 3.125% 4: 5: 3/32 = 9.375% 6: 11/32 = 34.375% 7: 16/32 = 50% NA: 1/32 = 3.125%
I would recommend it to a friend.	1: 2: 3: 4: 2/32 = 6.25% 5: 3/32 = 9.375% 6: 8/32 = 25% 7: 18/32 = 56.25% NA: 1/32 = 3.125%
It is fun to use.	1: 2: 3: 4: 5/32 = 15.625% 5: 6/32 = 18.75% 6: 9/32 = 28.125% 7: 9/32 = 28.125% NA: 3/32 = 9.375%
It works the way I want it to work.	1: 2: 3: 1/32 = 3.125% 4: 2/32 = 6.25% 5: 3/32 = 9.375% 6: 14/32 = 43.75% 7: 10/32 = 31.25% NA: 2/32 = 6.25%
It is wonderful.	1:

	2: 1/32 = 3.125% 3: 1/32 = 3.125% 4: 2/32 = 6.25% 5: 7/32 = 21.875% 6: 9/32 = 28.125% 7: 9/32 = 28.125% NA: 3/32 = 9.375%
I feel I need to have it.	1: 2: 1/32 = 3.125% 3: 1/32 = 3.125% 4: 3/32 = 9.375% 5: 4/32 = 12.5% 6: 10/32 = 31.25% 7: 10/32 = 31.25% NA: 3/32 = 9.375%
It is pleasant to use.	1: 2: 3: 4: 2/32 = 6.25% 5: 4/32 = 12.5% 6: 8/32 = 25% 7: 14/32 = 43.75% NA: 4/32 = 12.5%

Source: Based on Lund, 2001.

Besides the questions seen in Table 5, there was also a space for negative and positive aspects of the application. Five users have answered negative aspects and eight users have answered positive ones. They can be seen below.

Negative aspects listed by the users:

a) “It takes me some time to retrieve the information.”
b) “I would like to see charts comparing the data.”

c) “Country research gets stored. If I fetch for news of 10 different countries and try to go back, I need to click on undo 10 times to return to the landing page. And I’d like to see the infections curves as well.”
d) “Design.”
e) “I would like to see feedback from my symptoms if I have covid or not.”

Positive aspects listed by the users:

a) “It’s simple and direct. I trust the information provided by the app. User flow is linear and concise.”
b) “Easy to use. Minimalistic.”
c) “Easy to use and to fetch for information. Interesting to fetch news from different countries. Very good.”
d) “Easy, intuitive and with helpful information.”
e) “Good to fetch news from different countries.”
f) “Easy, clean, fast and intuitive.”
g) “Clean design.”
h) “Very useful.”

8.2.2 EQ-5D-5L

Besides the usability survey, shown in section 8.2.1, it was also applied to the users EQ-5D-5L. “EQ-5D-5L is a standardized measure for health status developed by EuroQol Group in order to provide a simple, generic measure of health for clinical and economic appraisal.”

In this survey, the user must answer how he/she is feeling in that day, in five different topics. Third-one users have answered this survey and their answers can be seen on Table 6.

Table 6 – EQ-5D-5L survey applied to the users

MOBILITY	
I have no problems in walking about	90.3% of the users
I have slight problems in walking about	6.5% of the users
I have moderate problems in walking about	3.2% of the users

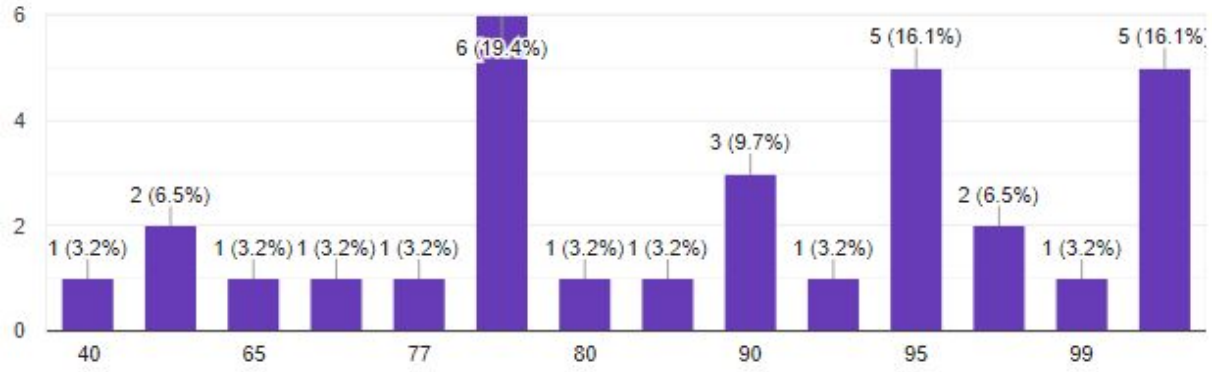
I have severe problems in walking about	
I am unable to walk about	
SELF-CARE	
I have no problems washing or dressing myself	93.5% of the users
I have slight problems washing or dressing myself	6.5% of the users
I have moderate problems washing or dressing myself	
I have severe problems washing or dressing myself	
I am unable to wash or dress myself	
USUAL ACTIVITIES (e.g. work, study, housework, family or leisure activities)	
I have no problems doing my usual activities	80.6% of the users
I have slight problems doing my usual activities	12.9% of the users
I have moderate problems doing my usual activities	6.5% of the users
I have severe problems doing my usual activities	
I am unable to do my usual activities	
PAIN / DISCOMFORT	
I have no pain or discomfort	77.4% of the users
I have slight pain or discomfort	19.4% of the users
I have moderate pain or discomfort	3.2% of the users
I have severe pain or discomfort	
I have extreme pain or discomfort	
ANXIETY / DEPRESSION	
I am not anxious or depressed	48.4% of the users
I am slightly anxious or depressed	32.3% of the users
I am moderately anxious or depressed	16.1% of the users

I am severely anxious or depressed	
I am extremely anxious or depressed	3.2% of the users

Source: EuroQol, 2009.

And at the end of these topics, the users have answered how good or bad was his/her health that day, on a scale of 0 to 100. A graphic with users' answers can be seen on Figure 39. As shown, 19.4% of the users have answered 79, 16.1% have answered 95% and 16.1% have answered 100.

Figure 39 – Users perception about their own health in a scale of 0 to 100



Source: Created by the author based on users answers.

9 WORKING PLANE

This chapter intends to show the working plane of this project, that is, the working team, all the costs involved and how long did every phase shown at the Methodology chapter took. All values and costs were considered in Brazilian currency, and then, converted to Euros.

At Table 4 is shown the staff who have worked on this project, and the value of their hour of work.

Table 7 – Value of the working hour

Employee	**Occupation**	**Value/Hour**
Gisele Gandin	Full-stack software developer	€ 8,50
Natália Karmierczak	Full-stack software developer	€ 8,50

Source: Created by the author.

Whereas that the project took 35 working days, and the staff shown at Table 4 have worked 6 hours a day, the total cost of the project, considering the hardware and the electricity as well, can be seen on Table 5.

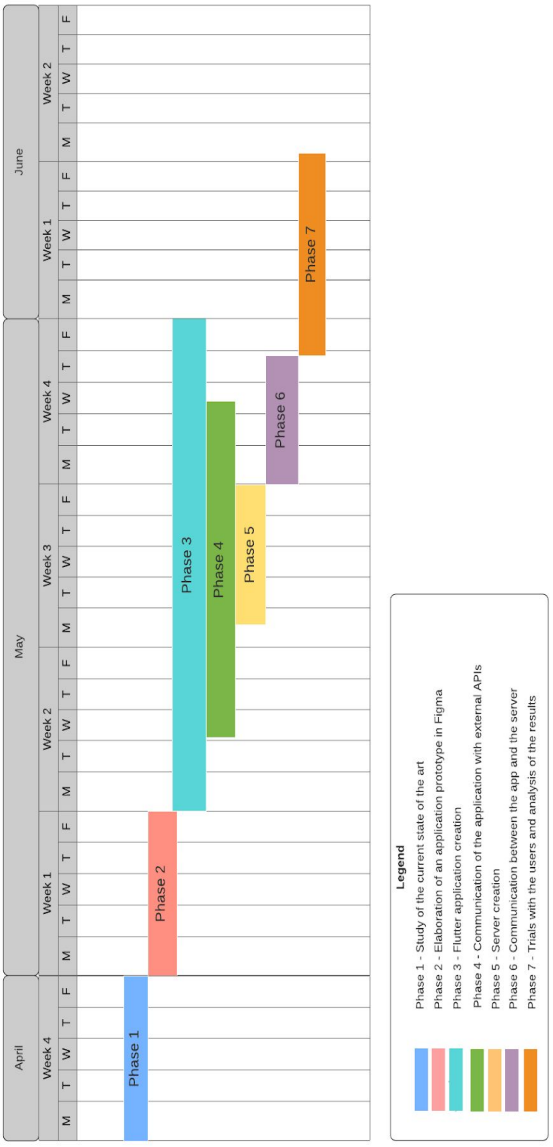
Table 8 – Total costs of the project

Description	**Amount**	**Cost**
Employees	2	€ 3570,00
Electricity	--	€ 30,00
Laptop computer	2	€ 1200,00
Smartphone with Android OS	2	€ 500,00
Total cost		**€ 5300,00**

Source: Created by the author.

And finally, at Figure 39 can be seen a Gantt Chart of the project, following all the steps, as better explained in chapter 5.

Figure 40 – Gantt Chart



Source: Created by the author.

10 CONCLUSIONS AND FUTURE LINES

This chapter is divided in three topics: fulfillment of goals, future lines and a conclusion, embracing the two.

10.1 FULFILLMENT OF GOALS

The main goals of this project were to design and implement a mobile application, where ordinary citizens could get reliable and updated data about COVID-19 and also for sharing their health status to an online database for future use. These goals were accomplished. And also (and probably, most important) this project aimed to be built on an architecture that could easily scale, and because of this accomplishment, there are lots of future lines that can be followed, as written next.

10.2 FUTURE LINES

Besides all the features that were already developed and implemented in this project, some future lines were mapped, but of course, they are only a few possible lines in an ocean of possibilities.

Some features that could aggregate value to the application can be seen in the list below:

a) Improve the application interfaces as a whole, in order to obtain a more solid and friendly layout, by interacting directly with a UX/UI designer;
b) Expand News Channel search bar to filter for keywords provided by the user — currently it only filter by “covid”;
c) Show graphics in both linear and logarithmic scale of confirmed cases, recovery ones, deaths and other data that could be extracted by the external APIs — for example, in some countries, it could be gathered how many people are being tested by day;
d) Create an authentication system for the user, so this auth could be used to validate both insertion and consulting of the database on server;

e) Provide a field in the application where the user can keep up with his/her symptoms history according to timestamp they were collected;
f) Anonymize the user to gather a “collective” outlook about the disease and explore this kind data as well.

And, of course, there are also all the features mapped in the Design chapter, that weren’t implemented mainly because of technical and ethical reasons, which would take the currently app to different directions, such as:

a) Track the populations mobility;
b) Watch for infected people nearby the user;
c) Verify the health system capacity by region;
d) Create a “good neighborhood” system, as explained in chapter 7, in which people who can’t go outside ask for people who can to buy essential items for them, such as food and medications.

10.3 CONCLUSIONS

This project has fulfilled its main goals and has also opened doors to future implementations and improvements. Although we live in the Information Age, and theoretically, it’s not very hard for people to get information on 2020, the application designed and developed in this project is useful not only because it aims to concentrate information about COVID-19 pandemic, but specially because of fake news spread and the lack of transparency in some governments.

On June 6th, 2020, in Brazil, where the authors live, the Ministry of Health decided not to inform anymore the total number of active cases and deaths in the country (FOLHA DE SÃO PAULO, 2020). Then, a few days later, by a decision of the Supreme Court, data was once again publicized. Besides that, on June 24th, it has been more than 40 days that Brazil don’t have a Minister of Health in office during this pandemic (FOLHA DE SÃO PAULO, 2020). This project, then, becomes even more relevant in this context, than it was in the beginning.

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