Determinants of Intention to Use the Contact Tracing Apps: A Case Study in Northern Cyprus

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ABSTRACT

Contact tracing is the process of attempting to identify people who have recently been in contact with someone diagnosed with an infectious disease in order to treat them. Digital contact tracing can be described in technological terms as a widely adopted surveillance system that its main purpose is to identify, evaluate and classify potential victims that's might have been exposed to an infectious disease.

This study aims to shed light on a common issue that is generally associated with a contact tracing system, which is privacy. Privacy of citizens is very important and should be highly regarded in situations like this. Getting users to install the contact tracing application is an issue that could be solved by developing an understanding and also mitigation of concerns and tradeoffs of user's adoption decisions, this study develops a validated extended Technological Acceptance model that proves that privacy concerns is part of the determinants of user's intention to use contact tracing apps but necessary tradeoffs can be made when it comes for health and safety of the user.

Keywords: COVID-19, contact tracing, data privacy, digital contact tracing, mobile phone apps

ÖZ

Temaslı takibi, bulaşıcı bir hastalık teşhisi konmuş biriyle yakın zamanda temas halinde olan kişileri tedavi etmek için belirlemeye çalışma sürecidir. Dijital temaslı izleme, teknolojik terimlerle, temel amacı bulaşıcı bir hastalığa maruz kalmış olabilecek potansiyel kurbanları belirlemek, değerlendirmek ve sınıflandırmak olan, yaygın olarak benimsenen bir sürveyans sistemi olarak tanımlanabilir.

Bu çalışma, genellikle bir kişi izleme sistemi ile ilişkilendirilen ortak bir sorun olan mahremiyete ışık tutmayı amaçlamaktadır. Vatandaşların mahremiyeti çok önemlidir ve bu gibi durumlarda çok dikkate alınmalıdır. Kullanıcıların kişi izleme uygulamasını yüklemelerini sağlamak, bir anlayış geliştirerek ve ayrıca endişelerin ve kullanıcının benimseme kararlarının değiş tokuşunun azaltılmasıyla çözülebilecek bir sorundur; bu çalışma, gizlilik endişelerinin belirleyicilerin bir parçası olduğunu kanıtlayan doğrulanmış genişletilmiş bir Teknolojik Kabul modeli geliştirmektedir. Kullanıcının kişi izleme uygulamalarını kullanma niyeti ancak kullanıcının sağlığı ve güvenliği söz konusu olduğunda gerekli ödünler verilebilir.

Anahtar Kelimeler: COVID-19, kişi takibi, veri gizliliği, dijital kişi takibi, cep telefonu uygulamaları.

DEDICATION

To My Dearest Parents and Family

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I will like to sincerely give God all the praise for the tremendous help he personally provided for me throughout this study.

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I dedicate this study to my dear mom Mrs. Olusola A Ayinke, whose love and prayers have brought me thus far.

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LIST OF SYMBOLS AND ABBREVIATIONS

AU	Attribute Towards Use
BI	Behavioral Intention
CFA	Confrımatory Factor Analysis
β	Cronbach's Alpha
MVC	Model, View and Controller
PEOU	Perceived Ease Of Use
PC	Privacy Concerns
PR	Perceived Risk
PU	Perceived Use
QR	Quick Response
SPSS	Statistical Package for the Social Sciences
TRU	TRUST
TAM	Technology Acceptance Model
UID	User Identification

Chapter 1

INTRODUCTION

1.1 Background of the Study

It is the twenty-first century, a glorious age of technological advancements and inventions, and yet we are confronted with another lethal virus know as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) or COVID-19.

Several control strategies have been established in the past to aid in the control of diseases that escalate to pandemic status, one of which is contact tracing. Contact tracing has been an excellent control measure in the fight against disease during the last century, as it has been improved on a regular basis. Countries such as South Korea, Germany, Australia, and a few others have achieved remarkable results in reducing the Covid-19 pandemic by the use of contact tracing and technology.

Except for the modern technology, the concepts behind this measure are considerably older; in fact, one could argue that the evolution of contact tracing began in the sixteenth century (great pox, syphilis). The journals of Christopher Columbus could be classified as one big data set during this era, as the celebrated anatomist Gabriele Falloppio, who served as chair of medicine at the citadel of medical learning during this era, would later use this journal to track the progression of the disease from the Americas to Barcelona hospitals and then to Italy during the siege of Naples (Conversation, 2020). Gabriele Falloppio and a group of other renowned scientists

later discovered that the soldiers hired by kings during these wars were responsible for the "super-spreader events" that elevated syphilis to pandemic status.

Gabriele Falloppio’s discovery during this era broadened physicians' understanding of disease transmission and the function of humans. Andrea Gratiolo, who pioneered a new way to contact tracking during the bubonic plague, embraced this concept. There is still dispute concerning the popularity of contact tracing in Europe at this age, and one could argue in its favor as the approach devised by a German hospital to bolster this claim. They had created a list of questions relating to how, when, where, and, if feasible, from whom to ask each patient seeking treatment between 1500 and 1700. This strategy may facilitate grouping and evaluating different persons who may be affected or may become sick in order to reduce human labor costs associated with tracing (Conversation, 2020).

Contact tracing protocols and strategies have evolved and altered over time in response to various infections, plagues, and pandemics. Another example of contact tracking is the Ebola crisis, in which millions of people were infected and some died. To contain and manage the virus's transmission, contact tracking was performed. Unlike the sixteenth century, when there was no such thing as big data, artificial intelligence, the internet of things, or other technological advances, technology has ushered in a new era of contact tracing known as digital contact tracing (Alam, 2020). As a result of the new corona virus, several countries have implemented the digital contact tracing inform of mobile apps (SARS-COV-2). After the world health organization declared a pandemic on March 11, 2020, citing over 118,000 instances of coronavirus infection in over 110 nations and territories worldwide and a persistent risk of global expansion.

1.2 How Contact Tracing Works

Digital contact tracing relies on technology to offer sufficient information on an infected victim's contacts, whereas manual contact tracing is not totally supported by technology. Both have the same objective, which is to battle and restrict the spread of infectious disease (Anglemyer A, 2020). After contact tracing, treatment or isolation is a critical control measure in the fight against infectious illnesses (Eames, 2003). The authors used a pairwise approximation method and full stochastic simulations to assess the utility of contact tracing (tracing efficiency).

Treatment and isolation become useless without contact tracing, as detailed in a document provided by the Center for Disease Control and Prevention (CDC), since everybody who tests positive or becomes positive, regardless of whether they are symptomatic or asymptomatic, should be addressed as a confirmed case. According to this article (CDC, 2020), priority classifications were used to determine the level of urgency with which contact tracing was deployed. In Table 1, these levels ranges from 1 to 4, with each level indicating a different degree of urgency.

Table 1.1: CDC's priority classification for COVID cases

Priority Classification Table	
LVL 1	People who work with large amount of people especially people in the public sector e.g., police officers, health worker, fire fighters and first responders
LVL 2	Critical Infrastructure workers, pregnant women and civilians who are 65 years and older.
LVL 3	People with symptoms and are not in the above level or category
LVL 4	People who are without symptoms and are not in the above level or category

The Centers for Disease Control and Prevention (CDC, 2020) classified contact tracing into four stages: exposure, contact interview, medical testing and monitoring, and close out. (Europa, 2020) classified contact tracing into the following stages: contact identification, contact follow-up, contact testing, and contact monitoring. When these categories offered by the leading public health organizations are examined closely, it becomes quite easy to identify similarities, and the very (healthmap, n.d.) sound notion of contact tracing begins to take shape.

Further investigation and analysis of these papers demonstrates that contact tracing alone is insufficient to combat infectious diseases, as illustrated by the groupings. A thorough examination of these classes reveals that both during and after contact tracing, groupings or priorities and multiple protocols must be established, which demands appropriate resources, including sets of highly qualified employees, to be managed effectively.

Comparing the two groupings offered with additional analysis, this study develops a comprehensive visual structure that shows how contact tracing works. Figure 1 shown below illustrates this structure visually.

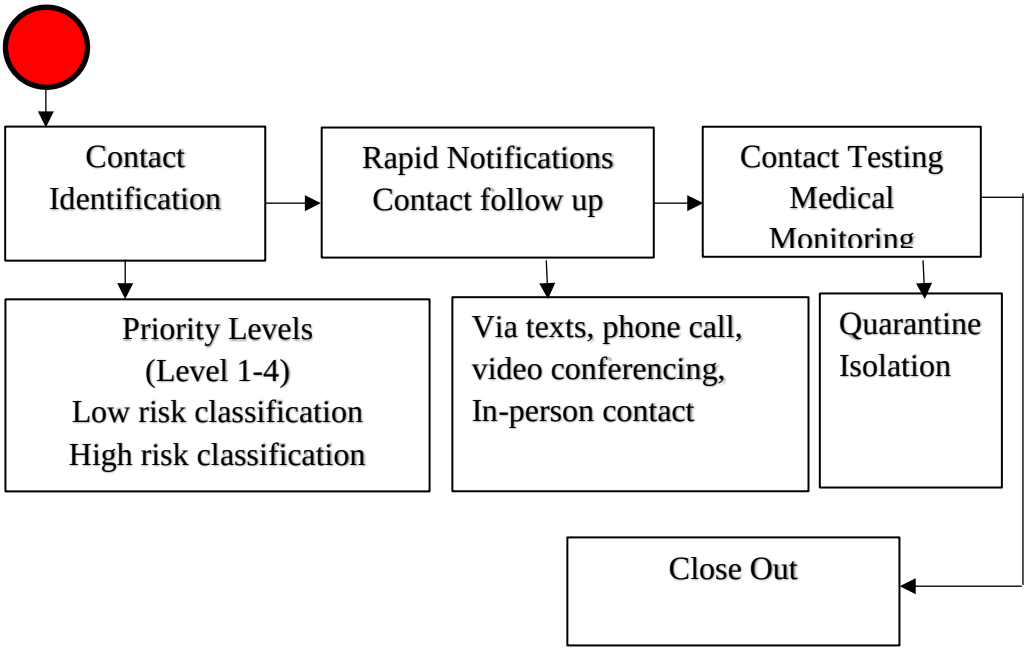

Figure 1.1: A contact tracing protocol diagram

1.3 Statement of Problem

The COVID-19 epidemic has spread like wildfire over the globe (healthmap, n.d.). Only a few industrialized countries have managed to contain the virus, and contact tracing is one of the measures or techniques utilized by these countries (Eames, 2003). In pre-digital eras - before to the advent of technology - contact tracing was performed manually, requiring a significant amount of manpower. In comparison to the current, with the rapid spread of the COVID-19 pandemic, contact tracing has become more challenging (Chappell, 2020).

Numerous developed countries have invested significant resources in order to improve the efficiency of contact tracing. Israel has enacted legislation granting government authorities access to the mobile call records of suspected infected individuals via tracking (Tidy, 2020). The South Korean government produces and maintains a public database that contains sensitive information about all infected patients' ages, genders,

travel patterns, and occupations (Denyer, 2020). Taiwan's government chose to let medical institutions access to a database containing sensitive information about patients, such as their travel records (C. J. Wang, 2020), and to grant local authorities access to the phone location data of those in quarantine. Finally, on March 20, 2020, the Singaporean government launched the first smartphone app that enables Bluetooth tracking when two persons using the app are or have been in close vicinity (Lee, 2020).

While some of the ideas listed above may have worked for them, it becomes extremely difficult for some other countries to accept them. The majority of these methods result in numerous privacy infractions, which do not sit well with other countries' societal standards and moral commitments. It is considered that the abovementioned measures are unlikely to be adopted in the United States. For example, disclosing patient information to the public is a breach of the federal HIPAA privacy rule (HIPAA Privacy Rule, 2000), and the fourth amendment protects individuals by prohibiting the government from accessing phone data without a warrant. In times of crisis, the HIPAA regulation can be waived to allow for telemedicine (States, 2018), and a well-argued emergency can be a public health emergency, as the COVID-19 epidemic has demonstrated. However, residents of the United States have a variety of reservations about providing their location and contact information with government or technical businesses, which might render this approach ineffective and difficult to change (hhs, 2020).

The Singaporean government's strategy of establishing an application provides users greater control over the process, which has the ability to contain and battle disease spread if the app becomes a regular practice for citizens. However, the program (dubbed TraceTogether) raises a number of privacy concerns.

Privacy is critical, and when professionals build an application's architecture, security, privacy, legal, and ethical considerations should be taken into account. A guarantee of privacy is required for the contact tracing technology in order to enable broad and easy adoption of stated systems (Jacobs, 2011).

1.4 Objective of Study

Northern Cyprus, which rates average in relation to the aforementioned countries, employs contact tracing but has not yet embraced drastic measures. Contact tracing is carried out manually, via paper trails, text messages, phone conversations, and in-person encounters, all of which raise several privacy concerns, as residents are asked to provide information such as their names, phone numbers, and other personal data. The current system's privacy difficulties are explored in length in this paper, along with other general connected topics, followed by the introduction of a new contact tracing method enabled by privacy-protecting technology.

Additionally, this study used the technology acceptance model (TAM) to ascertain the intention of Northern-Cyprus residents to use this new system via mobile apps. The approach employs perceived usefulness, perceived ease of use, user happiness, and use behavior theory to ascertain which elements contribute to the new system's acceptability. This study intends to address difficulties with the old/existing system and to gain a better understanding of the requirement design in order to assist the development of a more efficient model in the future.

1.5 Research Methodology

This study employs both qualitative and quantitative methods of inquiry. Several of the data sources are from various research professionals who have published articles, journals, and other resources on the issue. While the remainder of the analysis will be

undertaken using questionnaires (a quantitative technique) to ascertain the intention to adopt the proposed and produced system.

1.6 Outline of Study

This study contains six chapters with numerous sub-headings. The first chapter begins with an introduction to the study, outlining the study's context, aim, and issue statement. The second chapter contains a review of the literature conducted in conjunction with this study, as well as a discussion of the existing method of contact tracing in Northern Cyprus. The third chapter provides the developed system, including its architecture, as well as a description of the model for hypothesis analysis. The fourth chapter discusses the research methods and goes into detail on the terminologies and theories employed in this study. The fifth chapter analyzes and reports on the new system that was evaluated using data from surveys or questionnaires and structural equation modelling (SEM) to ascertain intention to use. The final chapter discusses the new system's issues and limits and also finishes the study.

Chapter 2

LITERATURE REVIEW

This chapter analyses and analyzes the currently accessible mobile phone apps for contact tracing on a global scale, utilizing search results from a range of electronic repositories such as Google Scholar, PubMed Central, and others. Between 18 and 31 December 2020, the following keywords were used in the search: (COVID-19 pandemic, Mobile Phone apps, contact tracing, prevention, data privacy and security).

According to the search results, fifteen countries are now utilizing seventeen mobile apps for contact tracing in the battle against the COVID-19 pandemic. According to the research, only three out of the seventeen mobile apps discovered, benefit from data privacy legislation, and Malaysia and China were both actively utilizing two of these apps at the time.

Additionally, the results indicate that these mobile apps perform functions such as monitoring self-isolated individuals, detecting individuals who are not wearing masks, and grouping individuals who may have been in close contact with an infected individual by providing transaction timestamps and other digital traces. After an extensive search and data analysis, the following is a comprehensive breakdown of the most popular contact tracing mobile applications, including a complete report and an accurate overview of each of the seventeen mobile apps now in use by these countries. Contact tracing is a commonly used surveillance technique capable of detecting,

analyzing, and classifying individuals who may have been exposed to or are at risk of contracting a pandemic disease. The digital contact tracing system, commonly known as "proximity tracking," is a surveillance technology that was intended to combat the COVID-19 epidemic (Parker MJ, 2020).

When it is necessary to determine whether two smart devices were in close contact when an individual became infected, the phrase proximity tracking is employed. A person is instantly contacted via technological or non-technological (in-person) means, allowing health officials to take required actions to contain future spread (Parker MJ, 2020). According to World Health Organization standards, nations must establish a surveillance system to collect vital and evidence-based data for COVID-19 research without jeopardizing the privacy of community people (WHO, 2020).

Proper use and adoption of the applications could result in increased contact tracking efficiency, particularly given that the vast majority of individuals in low- and middle-income nations own smartphones and are interested in utilizing the apps. However, these apps were produced quickly, and their development, privacy and confidentiality, user-friendliness, and popularity have not been fully compared and contrasted.

2.1 COVIDSafe

Australia was one of the first countries to be afflicted by the COVID-19 pandemic, with the crisis's severe impacts spreading across the country's many sectors, including healthcare, energy, banking, and tourism (Chang SL, 2020). As a result, the Australian government produced an app called COVIDSafe (Gov, 2020), making it the sole government-approved app. To function effectively, the app requires access to users' personal information such as their name, age, postcode, age range, and mobile phone.

Once registered, a verification number was provided to the user's cell via SMS. The mobile application's full functionality began on 26 April 2020. It utilizes Bluetooth signals to save data on the user's near contacts with other users, all of which are encrypted, making it a highly complex app. This contact-tracking application is still covered by data protection rules as a result of the Privacy Amendment bill (Gov, 2020). Once a user is identified with the disease, all subsequent communications are logged and stored in the database for later analysis and, most crucially, to help restrict the virus's spread. Although users can request deletion of their personal information (Legislation, 2020), this can only be done after the pandemic. Generally, the program cannot access the user's data or that of their close contacts and also deletes it after the pandemic, which creates security, privacy, and confidentiality concerns due to the fact that this can only be done remotely (Legislation, 2020).

2.2 BeAware

There is no country that is immune to COVID-19. We examine Bahrain, which, like the rest of the Arabian Peninsula, is a developing country. The first two cases were reported in February 2020, while the first death was reported in March 2020. As of June 2020, a total of 84 deaths and 26,339 cases had been registered (MOH 2020, WHO 2020). The gradual but consistent increase in the number of illnesses and deaths prompted the Bahrain authorities to develop the BeAware app (Bahrain, 2020). Bahrain's residents can now be tracked and monitored using wearable electronic bracelets that alert the government to any suspicious conduct. The user was responsible for monitoring the gadget, as each user in self-quarantine/isolation is expected to transmit images to the ministry on a regular basis showing their bracelets with their faces as proof of compliance with the program. Users who violate these restrictions

face jail time and other serious penalties. There is no data protection law applicable to this application.

2.3 Technology for Facial Recognition

China is the first country to document the harmful impacts that would eventually affect the entire world population. The first instance was reported in late December 2019 in Wuhan (Zhi,z. 2020). Numerous precautions were taken to prevent the virus's spread, including quarantine and self-isolation in impacted locations (WHO, china 2020)

Due to the rapid growth in COVID-19 pandemic cases and deaths, the Chinese authorities chose to repurpose an existing digital monitoring measure as a contact tracking system. Civilians can be tracked, detected, and monitored throughout the country using the technology. It is capable of detecting fever with an astounding 0.3oC accuracy margin and also recognizing those who are not wearing a face mask. The Chinese government created and implemented a variety of technologies to enable citizens to go about their daily lives, including a mobile payment system that enables contactless transactions between individuals. All of these technologies were developed and built to track each user's transactions, including their location, health, and financial information, which results in the creation of an infection risk score for each user. The Chinese government agencies supported this in order to determine the user's standing when using public and social services (Huang Y, 2020). There is no data protection law applicable to this application.

2.4 E-Rouska

Czech Republic reported its initial three cases in early March; since then, the country has seen a significant increase in the number of cases and deaths as a result of the pandemic. A collaborative venture of IT enthusiasts and technology businesses in the

country was formed under the auspices of the Health Ministry. The term e-Rouska, which translates as "e-facemask," was coined to assist hygienists in quickly identifying persons at high risk of infection. Only the hygienist has access to the data recorded as a result of these exchanges (CGAP, 2019). The software identifies persons who have had minor interaction with the exposed and assists in differentiating contaminated from healthy individuals. This application is governed by data protection legislation.

2.5 COVID-19 GH

This was Africa's first contact-tracking app, created in April 2020 by Ghana's ministry of communications and health in response to many incidents and deaths throughout the country. Following the app's successful debut and widespread adoption by Ghana's residents, the Ghanaian government recorded a test positivity rate of 3.18 out of 4786 individual instances (GHS, 2020). The software integrates with the country's mobile network platforms, recognizing positive cases through testing and tracking positive cases' contacts. There is no data protection law applicable to this application.

2.6 AarogayaSetu

After 89,995 confirmed cases and 5164 fatalities, the Indian government created AarogayaSetu, a mobile contact tracing app. The major goal of the app is to prevent the virus from spreading further by monitoring and tracking (MEIT, 2020). Among the apps reviewed in this article, AarogayaSetu has the most users worldwide and was built in 12 languages for the Android, iOS, and KaiOS platforms (MEIT, 2020). India is the only democracy that requires its citizens to download the app. However, the app has generated significant privacy concerns and challenges since its inception, owing to the country's absence of national privacy legislation, which creates ambiguity regarding who can access the app's data. There is no data protection law applicable to this application.

2.7 TraceTogether

Singapore's first instances were reported in early March 2020. To halt the spread of the deadly virus that has wreaked havoc throughout the world, Singapore's government began implementing public health measures (SNS, 2020). The application was created as a community-based solution to contact tracing, in which users can identify and inform other users when they become infected with the COVID-19 virus, allowing them to take required safeguards. Registration requires only a registered phone number, and data collected by the app is destroyed after 21 days if the user does not test positive during that time period (SNS, 2020).

Table 2.1: General summary of contact tracing apps

Name of the app	**Country**	**Method of data collection and type of data**	**Protected by Data Protection Law**	**Storage Policy**
AarogayaSetu	India	Tracks location and Bluetooth contact but also assigns color- coded badges indicating infection risk.	Not available	The information stored is deleted after 30 days in case a person wishes to opt-out
HAMAGEN	Israel	Uses GPS location of the phone to notify the user if s/he happens to cross a COVID19 positive person and provides the exact time and place of the encounter.	Not available	Not available
MyTrace	Malaysia	A community-driven application that assists users to exchange proximity information between each other once the app detects another device with the installed app	Not available	
MySejahtera	Malaysia	Personal data as, name, ID number, postcode	No	
NZ Covid Tracer app	New Zealand	Personal data, a digital diary of different locations that have been visited	Not available	

Smittestopp	Norway	Collects data about the movement pattern of the users, and in case of one them has been in close contact with another user who is diagnosed with COVID-19	Not available	The users' data is anonymized and data older than 30 days are deleted continuously
Tatamman	Saudi Arabia	The app provides services to identified cases for follow-up and lab test results as well as users who were in contact with confirmed cases	Not available	
TraceTogether	Singapore	Allows exchange short-distance Bluetooth signals; therefore, everyone can detect other TraceTogether users and alert whenever someone comes into contact with a COVID-19 patient to take the precautions	Not available	The data are automatically deleted every three weeks if the user doesn't come into contact with a positive case during this period
COVIDSafe	Australia	Name, mobile number, postcode and age	Yes	All storage data will be deleted after the pandemic
BeAware	Bahrain	Self-isolated individual's locations are traced and monitored by electronic bracelets	Not available	Not available

Facial recognition technology	China	The surveillance system can detect fever with a 0.3°C margin of accuracy and can identify individuals not wearing a face mask	Not available	Not available
Mobile payment systems (Ali Pay and We Chat)	China	Combine the users' data such as location, health and also financial data and then, generates a tailored personal infection risk status	Not available	Not available
The e-Rouŝka	Czech Republic	Only identifies the people a person has been in contact with by tracing the location	Yes	Data is only accessible for the epidemiological purpose
CoronaApp	Columbia	Symptoms, receive preventive advice and locating individuals	Not available	Not available
GH COVID-19 Tracker App	Ghana	Can trace anyone who has come in contact with an infected person	Not available	Not available
VirusRadar	Hungary	If an individual is infected, the app user will be asked to share the information with the health authorities.	Yes	Stored on the device for 14 days
Rakning C-19	Iceland	Tracks users' GPS data to collect information about the users' encounters	Not available	The data is stored only on the phone and is accessible only to the user. The information is

				stored for 14 days and then deleted.
Corona 100	South Korea	Tracks users' GPS data to collect information about the users' encounters	Not available	The data is stored only on the phone and is accessible by the user and Government health workers.

2.8 Contact tracing in Northern Cyprus

According to a news item posted by the media, the first incidence of COVID-19 in Northern-Cyprus was registered in March 2020. According to the news agency, the health minister stated that a 65-year-old German visitor tested positive for the coronavirus. It was then revealed that the tourist had arrived in the nation as part of a 30-person tour group (Aydogan, n.d.). As a result, the quarantine protocol was initiated for individuals who had close contact with, or tourists who flew on the same plane as, the first patient were exposed to SARS-CoV-2. A little while after the first positive case of SARS-CoV-2 was identified, safeguards were implemented in northern Cyprus, which are now being updated for the benefit of the local community (Nazife Sultanoglu, 2020). Despite swift action, the number of SARS-CoV-2 cases reported in northern Cyprus grew to 200 between 9 March and 4 May 2020. (Nazife Sultanoglu, 2020).

The government took precautions such as a total lockdown that lasted over a month and a complete shutdown of public gathering places such as clubs, movies, and restaurants (Ministry of Health, 2020). Residents were expected to provide information such as their names, phone numbers, and email addresses in order to assist police tracing potential suspects in the event of a positive case in that locality. According to (Nazife Sultanoglu, 2020), this was included in a press statement issued by Northern Cyprus's health minister. Government authorities have built a static QR code to allow residents to submit their information digitally if they do not wish to use the provided manual forms. As Mehmet, a random citizen, put it, "I'm not comfortable writing down my phone number to enter a supermarket." This statement raises severe privacy concerns and also restricts the effectiveness of the government officials'

contact tracing mechanism. The information supplied by a citizen is accessible to the next citizen in line, and if the majority of residents share Mehmet's opinion, incorrect information will be submitted, reducing the effectiveness of tracing. There has never been a mobile or digital contact tracing application in Northern Cyprus. While data indicate that manual contact tracing has enabled officials to effectively identify and locate a contact (Nazife Sultanoglu, 2020), the method continues to offer significant security and privacy risks. The government has started a quarantine tracking project dubbed "Guvende Kal." This would enable effective surveillance and control of self-isolating individuals entering the country. To the extent that an application is necessary that also requires private data, one can only inquire as to who has access to the data submitted and whether a system is in place to safeguard this data.

2.9 Discussion, Privacy, Security Concerns and Challenge

Numerous countries have created and are actively utilizing contact tracking applications exclusively for the goal of controlling the spread of COVID-19. The novelty effect that the apps have enables health authorities to monitor and diagnose infected persons. According to Amnesty International, some of these apps, such as Bahrain's BeAware, are being used as a major monitoring tool. It jeopardizes the user and their privacy through the app's active tracking features, which are frequently used without the user's consent (Cho H, Ippolito D, 2020).

The majority of these applications are supported and distributed to users via the Apple and Google stores, and are also available in the native language of the country, which is typically English. However, the issue of data anonymization, privacy, and usage persists (Amnesty, 2020), particularly with the involvement of Google and Apple, raising the question, "Are data rights being protected?" (Parker MJ, Fraser C, Abeler-

Dörner L, Bonsall D). It should be stressed that the mobile app should not be used in place of treatment; rather, it should be used to track infectious sufferers. While mobile apps may occasionally provide wrong data, which may result in false tracking and monitoring, with proper system maintenance and upgrades, they may prove to be more efficient. While mobile technology enables health authorities to track and diagnose infected people, extreme caution is required regarding the usability of these apps.

Chapter 3

THE DEVELOPED SYSTEM AND HYPOTHESIS

This chapter will present the developed system and also a review of research that used the TAM to explain user's intention to use the app. This includes, the overview of the system, the development method adopted in this phase as well as thorough details about the system design, the system architecture, the system's database design and other functionality of the system. The research that used TAM with further changes or additions will be discussed in the second section. The external variables, proposed hypotheses, and generated model will all be discussed.

3.1 System Overview

The concept of this app was based on examination of different apps. Several mobile applications has been developed in order to increase contact tracing efficiency. This approach to contact tracing is known as digital contact tracing. This software might be loaded on people's phones to inform them when they come into contact with someone who is pre-symptomatic, allowing them to self-isolate. By implementing such a system, it would be feasible to considerably accelerate the process of removing social distancing constraint. There have been similar solutions already in operation in chapter two but this solution proposes trust and transparency to users. In Northern Cyprus, the current system for contact tracing raises serious concerns in terms of privacy which technically could give minimize the efficiency of the contact tracing. Before the system's model was developed, there were several factors to be considered. Each of the factors that supports the idea of a contact tracing application, was to be

implemented as a function. Figure 3.1 describes the idea of a digital contact tracing application and was used as a guideline in this case. The leftmost part has day 1 and day 2 which represents a real life scenario whereby an individual performs his or her daily routines then ends up testing positive the following day. This thereby allows him to signal other people that the application has exchanged keys with about the current status.

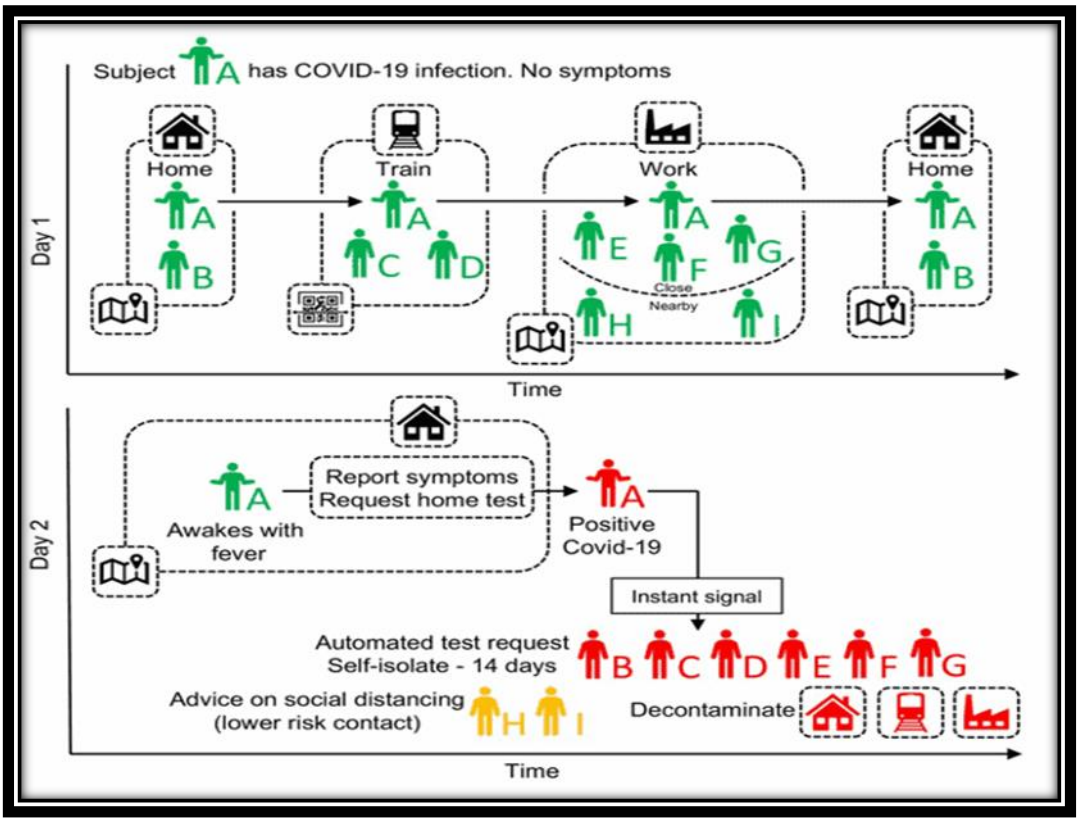

Figure 3.1: A Digital contact tracing system (Ferretti, 2020)

3.1.1 System Development Method

The development method considered for this application was the Incremental Development. In this part, the complete system design is completed first, leaving out details that can be later decided on. After this, the completed design will be broken down into parts and completed to build a working prototype. At first, this was very doable in this scenario because only the functions that makes up a contact tracing

system will be included while other things that can make the application more user friendly and solid can be added on later. I initially chose this method because the software can be delivered early as time could be a factor. Also, only the important parts could be focused on while leaving out other parts for later.

Although, this approach is suitable for this study now, for future development on this study, especially on the system, a better approach like the agile method of development will be used because the incremental development approach is not adaptable to changes in its requirement, unless it is combined with another method. Apart from that, the product also won't be completed until every part is in place. Figure 3.2 presents the developed application can be seen below.

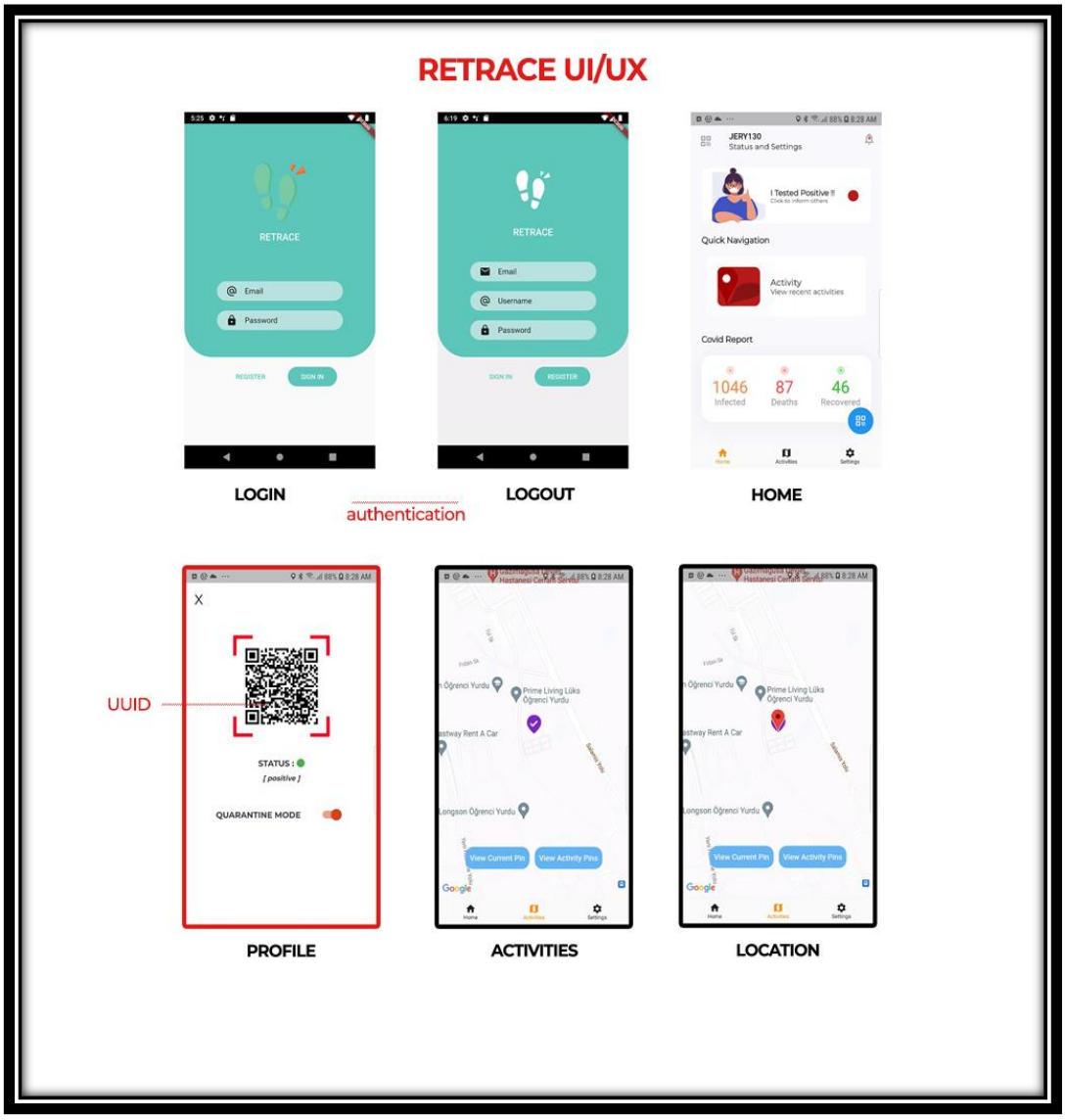

Figure 3.2: The developed system interface (retrace)

3.1.2 System Data Model

The name of the system developed is called RETRACE. It uses a location based tracking method to perform contact tracing. This basically allows the system retrace the steps of a user for the last 14 days if tested positive then notifies the contacts within these days. The system model allows a user to have a unique user ID (UUID) upon registration with an email address as the only information required during registration. The model requires an email address in order to enable a two way verification of the user's status. Upon registration, the user is automatically giving a unique QR code that

allows business and public places have access to your current status upon scan if there is no internet to perform a QR scan by the user. Hence, providing an email enables the program to have an efficient unique code for each user.

The application also makes use of dates and timestamps known as transaction in order to ensure accuracy when notifying recent contacts during tracing. Additional datasets might include location tracking which is not a compulsory function, but might be useful for self-isolating individuals.

The application is divided into three views, for easy development and maintenance. The said view are,

I. **The user view**: This view has a user-friendly interface that makes it easy to use and understand. This view is general for every user that uses the app. It has three pages, a home page, a profile page and an activities page. There are several functions available to the user. The user has the ability to send his or her location as a form of check-in. Another functionality available to the user, is the ability to scan a dynamic QR code so as to enable the business view of this application get access to the current status of the user. The most important functionality that is available to the user, is the ability to notify other users that have been in recent contact, if the said user becomes infected or tests positive.

II. **The business view**: This view also has a user-friendly interface that makes it easy to understand and use but with a more different content than the user. The business view is given a part of an admin privilege, in which the local business moderator can know your status after scan. The local business view or implemented system is only capable of generating unique QR codes to the user. The unique code that is dynamically generated consists of the coordinates of the business, the timestamps and

also the merchant id as well as the merchant name, all embedded and pass through via an API call in order to generate the QR code.

III. **The admin view**: The admin view has a more professional look. This part of the app controls and manage every aspect of the application.

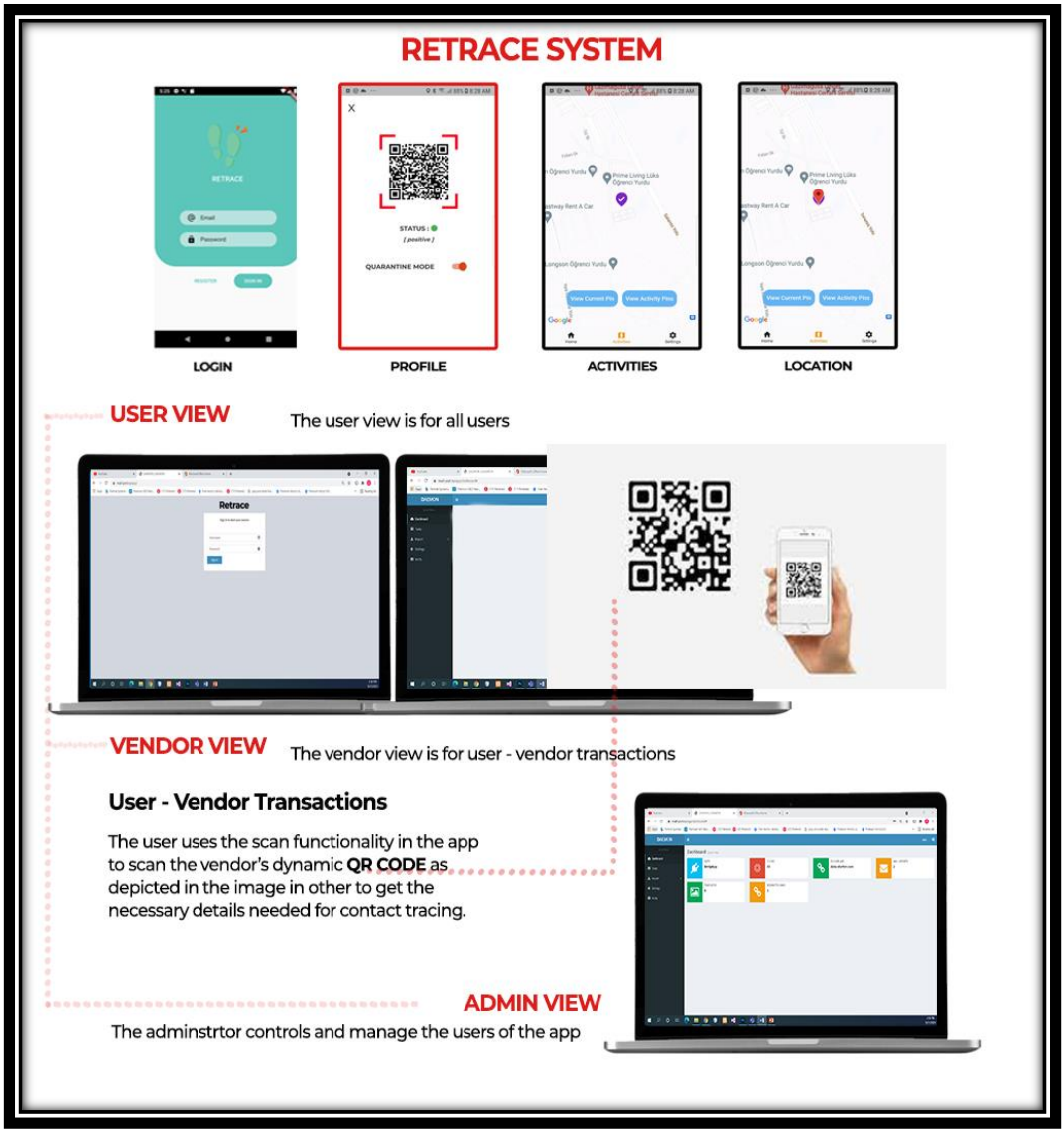

Figure 3.3: A diagram of the developed system views

Figure 3.4: A diagram of the system transactions

3.1.3 Hardware and Software Requirements

Throughout the development of application, the Android studio ide was used. A very detailed explanation can be seen in tables 3.1-3.2 below.

Table 3.1: General summary of software requirements

Environments Supported	Version
Xamp / Wamp Server	for Windows 6.6.32 or higher
Android Studio Ide	3.1 or higher
Flutter, dart	Version 2.1 or higher
PHP	PHP 7.6.32 or higher
JavaScript and Jquery	Version 3.6.0 and higher

Table 3.2: General summary of hardware requirements.

Hardware	Version
Central Processing Unit	Intel i5 or Higher
Ramdom Access Memory	8GB or Higher
Android OS	OS v 11

3.1.4 Programming Languages

The application was developed using flutter framework which uses the Dart language and Google's Cloud Firestore. The Dart language is similar to java and it also supports Object Oriented Programming. The flutter engine was used in the development of the user view, for the business view, which is mainly for the local vendors, pure HTML with CSS was used, while the admin view also uses HTML with CSS.

3.1.5 System Architecture

The system is currently in beta stage and has been tested and used by various users. The system is currently using a Client/Server Architecture in order to accommodate future changes. To operate this technology at a population-scale, rigorous architecture design is essential to assure the solution's Consistency, Integrity, and Availability, as well as to ensure that the data is not vulnerable to unauthorized access.

3.1.6 System Design Architecture

The application uses a MVC design architecture. This architectural pattern separates the application into three logical components Model, View and Controller. The project utilized this pattern in order to separate the business logic from the presentation layer. The View component is for user interaction which is controlled by the Controller. The Controller updates the Model which then notifies the View. Using this technique allows for easy changes or updates to the system. Figure 3.5 shows the current design architecture of the system.

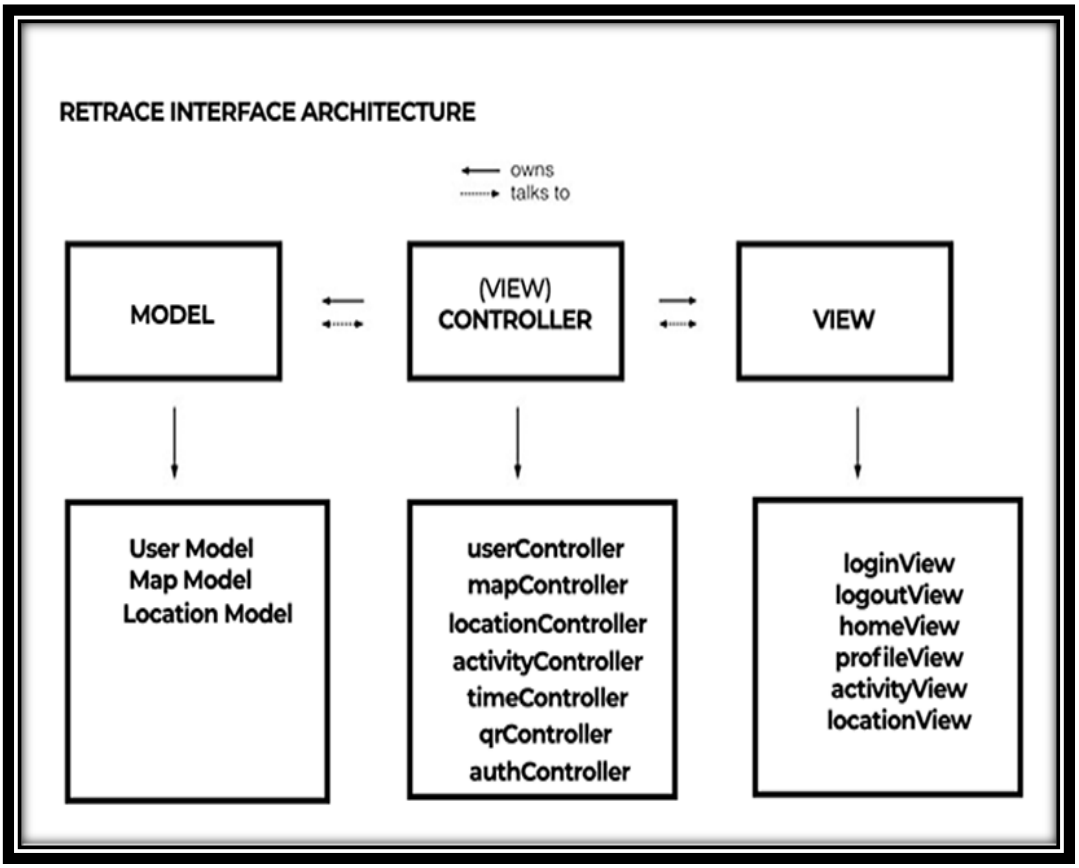

Figure 3.5: A diagram of the developed system design architecture

3.1.7 Storage/Database Management System

The system is currently using Google's Cloud Firestore. The Google Cloud Firestore is a NoSQL document database that lets you easily store, sync, and query data for your mobile and web apps - at global scale. Although the engine allows scalability for future expansions, a more ideal solution is required that can deal with high throughput and fast random access and performance when retracing user's steps for notification. The current database entities are described in Figure 3.6.

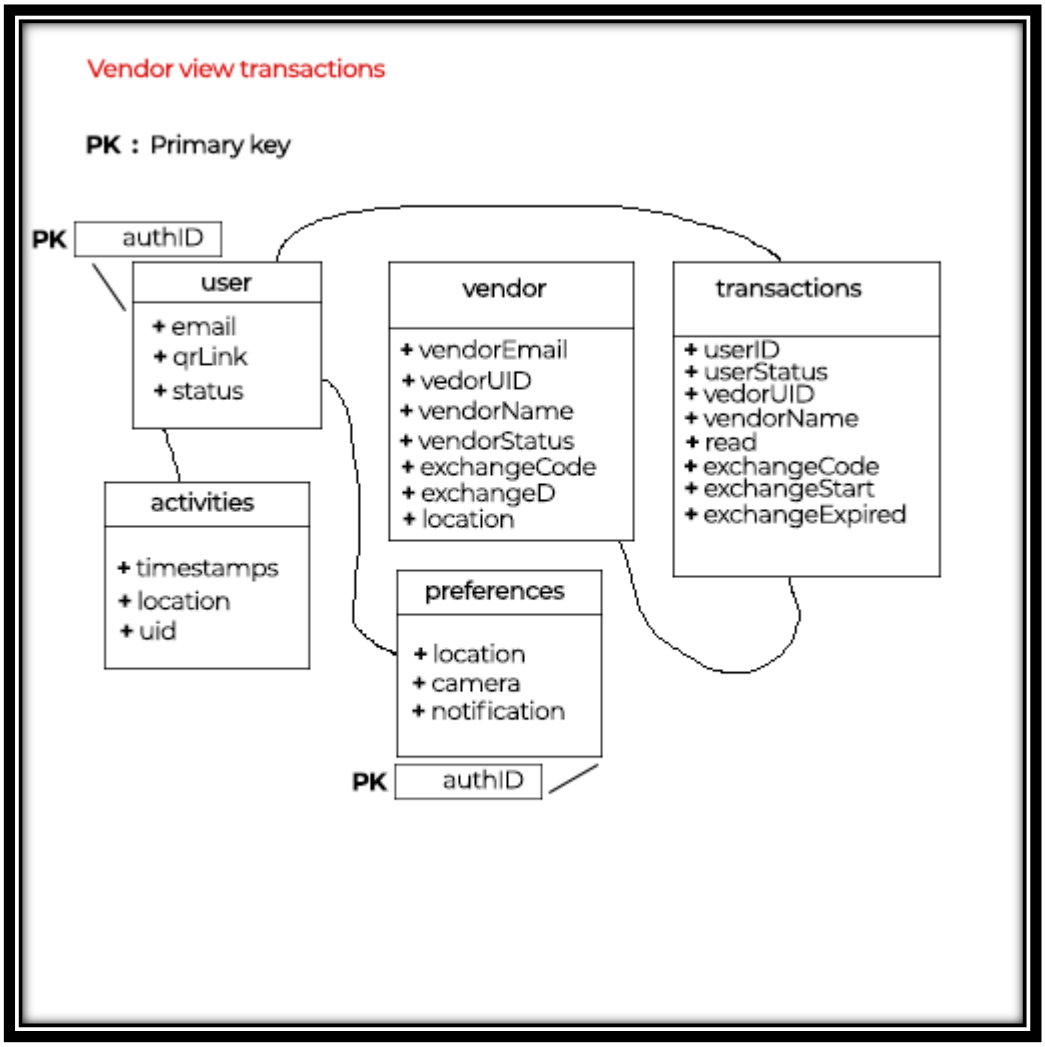

Figure 3.6: A diagram of the developed system's database

3.1.8 Maintaining Privacy

The system is currently taking advantage of the Google's platform block-chain technology that is currently incorporated with the Cloud firestore database as the only bit of user information that the application requires is the user's email address which is encrypted before storing by the application's algorithm to prevent unauthorized usage. Other data stored by the app are the data that willingly supplied by the user such as location and timestamps, as only the user can check themselves into a particular location.

3.1.9 System Functional Requirements

The functional requirements or capabilities of the system are described in the table shown below. A brief explanation is given in table 3.3 to better understand the developed functionality of the system.

Table 3.3: General summary of functional requirements.

REQUIREMENT ID	DESCRIPTION
FR. 1.1.	The system shall allow users to perform any form of authentication before using the app
FR. 1.2.	The system shall allow the user to view its unique id (UID)
FR. 1.3.	The system shall allow the user have access to the information supplied upon registration.
FR. 1.4.	The system shall allow user to be able to send their location (Optional)
FR. 1.5	The system shall allow user to be able to see their location activities in the last 24 hours.
FR. 1.6	The system shall allow the user to inform others when they test positive or become infected.
FR. 1.7.	The system should have the geolocation services enabled.
FR. 1.8.	The system shall perform operations with the camera such as e.g. scanning QR codes.
FR. 1.9.	The system shall calculate and check for recent contacts of an infected person in other to notify them for immediate self-isolation.
FR. 2.0.	The system shall update the user's unique ID every hour for security reasons.
FR. 2.2.	The system shall allow the business view the ability to generate dynamic codes for user transactions.
FR. 2.3.	The system shall allow the user to have a persistent login i.e. the user can return to the system anytime without having to login. Manually signing out, overrides this functionality.
FR. 2.4.	The system shall allow the user log off but will request the user's location history upon signing in.
FR. 2.5.	The system shall notify the user upon a successful scan in other to acknowledge the transaction.
FR. 2.6.	The system shall notify the user to enable the required services. All which are saved as preferences to avoid future requirements.

FR.2.7.	The system shall allow for daily tracking once the user becomes positive.

Figure 3.7: A diagram representation of the functional requirements

3.1.10 System Non-Functional Requirements

The Basic Non-functional requirements for any system or mobile application development are also listed below in table 3.4,

Table 3.4: General summary of non-functional requirements.

Performance	Retrace will have the capacity to entertain a large number of users

	without them experiencing any lag in the system.
Availability	The system will be made available at any time of any day.
Usability	The system will be easy to use and also easy to understand by any level of computer and non-computer literate
Accuracy	The retrace system should be able to get processed and accurate information only.
Maintainability	Updating the system will be done in order to maintain and update the packages used for this development
Recoverability	Back up and duplicating user data shall be done in order to prevent complete loss of data.

3.2 The Technological Acceptance Model

The Technology Acceptance Model is widely accepted by academics (Davis 1985, Bagozzi, and Warshaw 1989). (Szajna, 1996 and Hong, Thong & Tam, 2006). TAM has two parts: independent factors like PU and PEOU, and the dependent variable Attitude toward Use. In contrast, the researchers define PEOU as a person's perspective that using a system is simple and easy (Davis, 1989). A user's behavioral intention is defined by their attitude toward the system's use and perceived benefit (Davis, Bagozzi, and Warshaw 1992). (Liu, 2015). TAM has two parts: independent variables like PU and PEOU, and dependent variable AU. The authors describe PU as a person's perspective that using a system will improve their performance, while PEOU is a person's belief that utilizing a technology is simple (Davis, 1989). They also emphasized that the customer's BI is achievable by its combination with customers' AU of the system's use and PU (Davis, Bagozzi, and Warshaw 1992). (Liu, 2015). These variables include trust (G.Karahana, 2003; Chin and Wu 2005), PR (Lee cho, 2009).

3.3 The Research Hypothesis

The interactions between model variables in TAM study should be governed by the assumption that they are required (Venkatesh and Davis, 2000; Park). The research theories are derived from the connections in the built model when the orientation of every link between variables is regulated. Moreover, the hypotheses allow the study to examine the likelihood (i.e. significant level) and standardized coefficient of any link between the variables (e.g. prediction value). This is a common strategic approach in focused research, which first and later tests study hypotheses. In the following sections, the investigation hypotheses for each variable are justified.

3.3.1 Behavioral Intention (BI)

The epidemic of COVID-19 resulted too many economic crises, victims, deaths and daily activities (Remuzzi & Remuzzi, 2020). Various governments have implemented innovative technology such as the digital mobile contact tracing as a kind of Eco social movement in the next phase of this epidemic. While there are strong recognition of IT capabilities in the health sector (M et al., 2008; B et al., 2011), and fewer user resistance in adopting technological health systems (Kamal, Shafiq&Kakria, 2020). The employment of the Technology Acceptance Model therefore determines the attitude of the users to find out what implications their decision to adopt this technology will have. In this study, the health factors (Hu, Griffin & Bertuleit 2016), which develop a comprehensive technological acceptability model, were applied.

3.3.2 Attitude towards Use (AU)

The TAM framework defines AU as a user feelings and thoughts on utilizing a system (Davis, Bagozzi & Warshaw, 1992). The TAM model (Yang & Zhou, 2011) and mobile health can be utilized to substantiate the association between the variables (Cho, 2016). Thus, the following theory is possible:

Hypothesis 1: A user's attitude toward an app influences their behavioral intention to use it.

3.3.3 Perceived Risks (PR) of COVID-19

The PR for developing COVID-19 came from a previous study written by a group of researchers (Fisher, Reynolds & Napper 2012). The role that risk plays in determining behavioral tendencies of humans cannot be overstated. The term "perceived risk" relates to a person's perception of uncertainty when making decisions (Nicolaou & McKnight, 2006). In this study, consumer acceptability of an App is determined by PR. According to research, perceived risk increases negative outcome predictions, lowering intention to use (Hsieh, 2016). Thus, the following hypothesis can be proven:

A favorable behavioral intent to utilize this app is influenced by perceived risk of COVID-19 exposure.

3.3.4 Perceived Ease of Usefulness (PEOU) and Perceived Usefulness (PU)

PU can be described as the usefulness of a system when integrated into daily life of a user (Davis, 1989). PEOU is the degree of simplicity in usage that a system or technology possess (Elkaseh, Wong & Fung, 2016). People will accept and use this software if it benefits them, according to the survey. (Sánchez Franco et al., 2007) The TAM model asserts that PU and PEOU influence an individual's AU of the application. So, here's one theory.

Hypothesis 3: The applications' PEOU improves the user's attitude towards it.

Hypothesis 4: The application's PEOU improves perceived utility.

Hypothesis 5: The application's PU improves the user's attitude toward it.

Hypothesis 6: The application's PU influences the behavioral intention to utilize.

3.3.5 Privacy

Previously, privacy was used alongside the TAM model (Zhou, 2011; Ambrose & Basu, 2012). Confidence in a technical system, in this case a mobile application, that personal health information will be utilized solely for the purpose for which it was provided and will not be compromised in any way (Kakria, Kamal, & Shafiq 2020). Previous studies found that privacy influences technological acceptability (Palos-Sanchez, Saura, & Martin-Velicia, 2019). 2016 (Lin & Kim). When discussing medical information, privacy is paramount. As a result, consumers wary about revealing personal data with a health APP may not utilize it. Thus, the following theory is possible:

Hypothesis 7: Privacy concerns about an app reduce the likelihood of using it.

3.3.6 Trust

Customers' trust in a new technology's services to achieve positive outcomes (Kamal, Shafiq & Kakria, 2020). This study's goal is to boost users' trust in API technology and thus their preparedness to utilize COVID-19 virus-related applications that utilize geolocation. Thus, the following theory is possible:

Hypothesis 8: trust in an app improves use behavior.

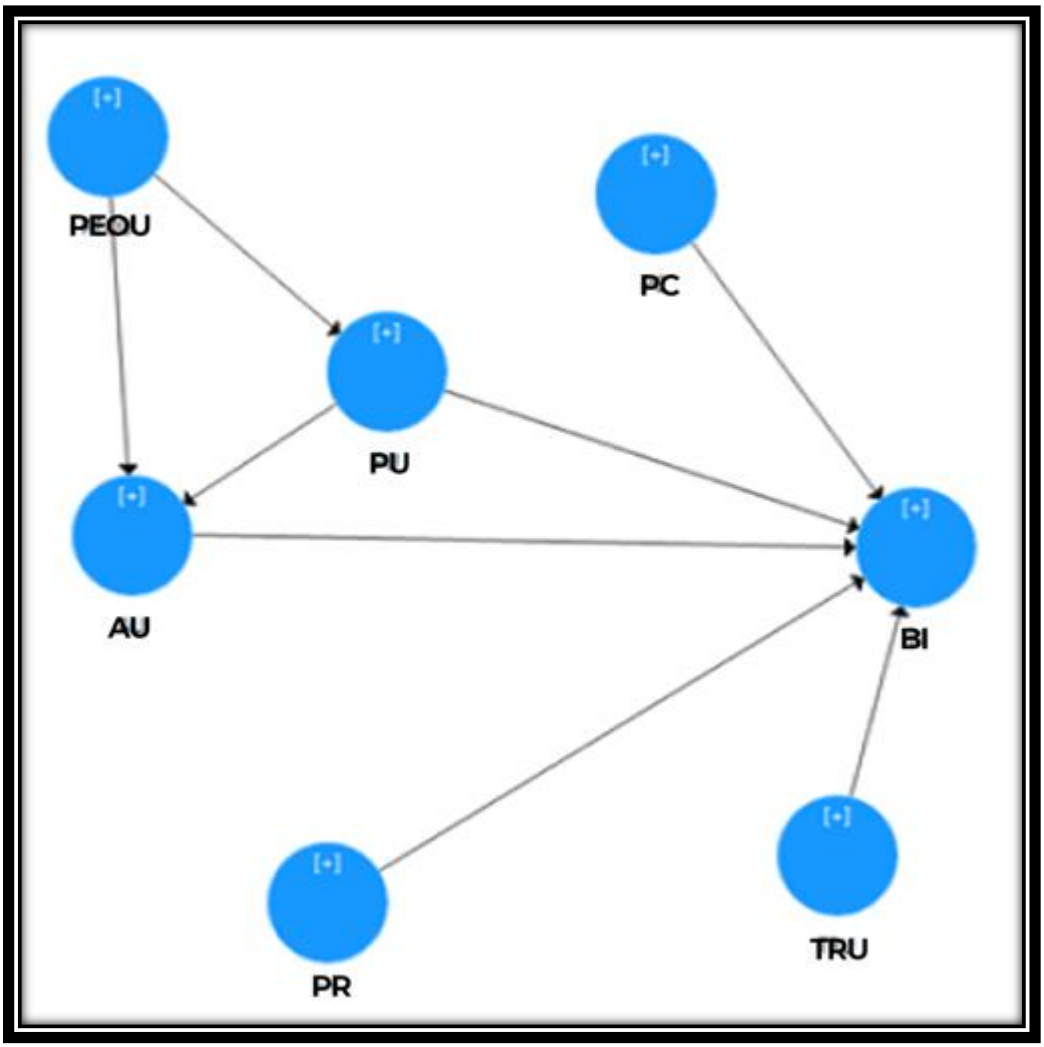

Figure 3.8: The developed model with extended variables

Chapter 4

THE RESEARCH METHODOLOGY

Methodologies such as to describe, analyses, apply, statistical, descriptive, investigative, deductive, exploratory, and confirmatory research can all be successfully used to accomplish research objectives (“Hussey and Hussey 1997; Fitzgerald and Howcroft, 1998”). The intention of consumers to utilize a contact tracing program was examined using a technical acceptability model developed specifically for this study. In this part of the study, we will discuss the study's method, design of the study, population, sampling strategy, information gathering, and analysis of data.

4.1 Research Method

Research uses deductive and inductive methods. The inductive technique is defined as "the process of examining specific facts and drawing inferences" (Sekaran, 2003). The inductive approach starts with an observation and ends with a theory or hypothesis to explain the observation (Lancaster and Crowther, 2008). According to (Saunders et al., 2012), the inductive technique describes a phenomena to better comprehend the topic, then provides theories to further explain the discovered events. The inductive inquiry explained below was written by Donnelly and Trochim (2005): The first step is to look for patterns in the facts around you. Second, patterns can be used to generate ideas and hypotheses. The inductive method is very useful for interpreting data from means of qualitative research (Lancaster & Crowther 2008).

"A set of techniques for validating and testing theories in the real world" described by Lancaster (2005). A top-down strategy describes deductive research that empirically tests prior beliefs and notions (Lancaster, 2005). According to Saunders et al. (2012), deductive research is "the formation of a hypothesis that is rigorously tested." This study's goal is to develop a technological acceptability model for determining user intent to use a contact tracing application. The proposed model will also be empirically validated and rigorously tested. Lancaster (2005) recommends four steps for deductive research:

Initial theories are developed on the ideas, prior knowledge, a review of literature, or desire to solve a given problem by the researcher. To answer the research question, all of this information can be logically combined. This project will undertake a comprehensive literature evaluation on technological acceptability.

That's followed by operationalization, which requires detailed description of all ideas employed in theories or hypotheses. This method removes any ambiguity about what should be measured and how (Burns, 2000). This study's goal is to create a model of technological acceptability that can predict user interest in contact tracking programs. The model has seven variables and eight hypotheses directing their relationships. Also, all variables and measurement items shall be established.

The third is empirical validation. On this stage, you will focus on research strategy and design. Topics for research will define research strategy and design. This study validated and assessed the developed model quantitatively.

Finally, the study theory or proposition may be approved or rejected based on the findings. This study will use SMARTPLS to do CFA and multiple regression. The study's findings will be compared to the model and hypotheses proposed.

4.2 Research Design

Depending on the investigation, the research design may be qualitative or quantitative. Qualitative research seeks to understand real-life occurrences, “where the researcher does not try to change the observed phenomenon”. QSR is naturalistic, reason being that the focus is on people’s live, including the world they live in. (Armour & McDonald, 2012; Denzin &Lincoln, 2005) also mentioned that qualitative research shares many similarities with quantitative research. Initially, the researcher collects data. Second, the researcher often conducts fieldwork, visiting people at work to collect data via observational interviews. Third, qualitative research uses inductive research methods to build knowledge.

Webster (2004) divides these approaches into three categories: This study uses field and lab experiments as well as surveys. Experiments can reveal what works and what doesn't. Because they control the testing environment, they can establish causal correlations. However, surveys allow for a larger sample of the research population and provide a more complete picture of the population's cross-sectional state at a given period.

This study uses a quantitative method, collecting data via questionnaires because questionnaires allow you to contact large numbers of people. Finally, Sekaran (2003) offered the research design criteria that support the questionnaire's use in this study:

1. The Study's Purpose: An exploratory technique is used first when little is known about a phenomenon. The exploratory technique examines and contrasts theories and facts. It's time to update concepts (Gerring, 2001). (2001) Inductive research allows for the revision of hypotheses because they are easily generated and only require factual validation.

I created a model and theories based on the existing contact tracking system in Northern Cyprus to assess user acceptance.

2. Study Setting and Researcher Interference: The study's setting influences how much the researcher intervenes. It may be accidental. In a causal study, the researcher aims to outline the causal relationship. In a correlational study, “the cause of one or more problems” is investigated. This study examines the relationship between the seven variables and the user's purpose. The study also affects researcher interference. Causation researchers are prone to inappropriate interference. The experiment's flow determines cause-and-effect. Using questionnaires, for example, allows for minimal interference in a correlational study, causing no hardship to employees (Sekaran, 2003).

3. Time Horizon and Analysis Unit: The unit of analysis is the “level of analysis”, data aggregation step (Sekaran, 2003). Individuals are the study's unit of analysis. This study will collect data from each participant individually via questionnaires, with results collated into a single data table. Also, surveys allow for cross-sectional research when data is collected in segments over time (days, weeks or months). The study's findings are as follows: a method of collecting data from university students and citizens over time (five weeks).

4.3 The Population

Subjects that the researcher is interested in exploring are known as populations (Sekaran, 2003). Northern Cyprus men and women studying at the undergraduate level make up the demographic of this study, as they are acquainted with contact tracking. The Ministry of Higher Education estimated that there were about 60,000 students enrolled in the colleges, meaning that 60,000 of them may be employed for this research. The population was so huge that a self-selected sample frame was utilized (Saunder et al., 2013).

In SEM, 20 participants per independent variable were required (in other words, 20 respondents were needed for each independent variable). Also it was concluded that a 50:1 ratio produced the best results. A dependent variable, or factor, was constructed to gauge utility. A total of 300-400 individuals were surveyed, resulting in a 50:1 sample size (Hair et al, 2010). A total of 337 replies were included for statistical analysis. The statistical study will use all of the 337 respondents' answers. To check the model's one-dimensionality, we shall do confirmatory factor analysis.

Bootstrapping analysis will be employed to determine whether the hypotheses are supported or refuted by the 337 replies. Hypotheses can only be accepted if their probability value is lower than the given number (0.05). For accepted and rejected hypotheses, you must both calculate the standardized coefficient for the verified hypothesis alongside the rejected hypothesis. The estimation of the explained variance in the 337 responses will be performed with a regression analysis based on the following: PU, PEOU, PR, PRI, TRU, AU using the application and BI.

4.4 Population Sampling

The selection of a suitable number of components from a population is the procedure. Since it's impossible to survey the entire study sample because of limited time, budgetary, or geographical constraints, it's quite valuable (Saunders et al., 2009). Two common sampling techniques are probabilistic and non-probability. As a research methodology, probability sampling posits that every member of the population has an equal chance of being selected. Probability sampling relies on a sample frame, which is its most critical component. All members of the sample frame will be chosen for sampling (Sekaran, 2003). Since a sample frame is required for probability sampling, non-probability sampling must be discussed. Researchers have a number of options for sampling their study population when a sampling frame is unavailable. Because of the following reasons, non-probability sampling will be used to choose study participants. A study population's size is too large to poll. Second, it is impossible to get the sample frame in Northern Cyprus because of its COVID protocols. A self-selection sampling strategy was used in this investigation. Participants in study can freely choose to be involved using this sampling technique, and the researcher is not able to influence their decisions (Saunders et al., 2009). To get participants, the researcher must choose a suitable media. Furthermore, you should interview the individuals who took part in the study.

All participants were emailed, and they were asked to take part in the research.

4.5 Data Gathering

Data collecting is a crucial element of research design, and it entails selecting an acceptable method (Saunders et al., 2009). In the previous section, the study describes the usefulness of questionnaires as a data collection tool. The steps of instrument

development will be detailed in the next section. “All techniques of data gathering in which each respondent is asked to respond to the same set of questions in a preset order” is what the term questionnaire refers to (Saunders et al., 2009). In general, using a questionnaire is not expensive, very fast, distributed worldwide, and allows volunteers to respond freely (Saunders et al., 2009; Bryman and Bell, 2007). In addition, there are two sorts of question surveys: self-administered and interviewer-administered. Respondent characteristics, respondent importance, manipulating respondents, sample size, sample type, and number of questions are among the five criteria proposed by Saunders et al., (2009) for selecting an effective strategy. The research subject are students, the required sample size is large, the kind of questionnaire described utilizes the Likert-scale, and the number of questions is quite high, a self-completed questionnaire was chosen based on the aforementioned criteria. Furthermore, in the technology acceptance domain, self-completed questionnaires are frequently used as the primary method of data collection (e.g., Ong et al., 2004; Raaij and Schpeers, 2006). (Liaw, 2008; Hsia, 2007; Roca and Gagné, 2008), (Jong, 2009), (Lee, 2009; Park, 2009; Sánchez and Hueros, 2010; umak et al., 2010).

4.5.1 Survey Development

The contents of a questionnaire affects the response rate of the data (Saunders et al., 2009). “The respondent must comprehend the inquiry as intended by the researcher, and the researcher must comprehend the respondent's response as intended by the respondent,” says Foddy (1993). This study's questionnaire was prepared in phases to ensure that it is valid and reliable. It is necessary to identify the measured variables that will be used to assess the model variables. The external variables' measurement items were chosen from the literature. According to Hair et al. (2010), each variable in the model should have two measurement items. The study found 34 measurement

items for the variable of the model. The adopted measured variables were modified for this investigation. Next, pick the proper inquiry type. The Likert-scale is a direct question form used in consumer technology acceptance tests. On a four, five, six, or seven-point rating scale, participants were asked how strongly they agreed or disagreed with a statement or group of assertions (Saunders et al., 2009). In this study, strongly disagree is the lowest Likert scale, and strongly agree is the highest. Also, a statement of agreement is entered in, and users are asked to rate it on a five-point scale. The final stage is to develop the questionnaire layout. It is important to have a professional looking questionnaire with clear and precise order of questions (2007). A good question design reduces chances of getting errors and missing data. As a result, self-completed questionnaires should be designed to be straightforward to read and answer. Also, a pleasing layout for the questionnaire design will encourage consumers to finish the survey (Saunders et al., 2009). This study's questionnaire was designed utilizing an internet survey tool (surveymonkey.com). The same is true for Dilman (2007). The questionnaire cover page outlined the research purpose, as well as voluntary participation and data confidentiality. Test for validity, dependability, mistakes, and omissions is the fourth stage (Dilman, 2007 & Saunders et al, 2009). Pre-testing of the survey questions included two rounds:

• First, a PhD researcher and a senior lecturer reviewed a manuscript. This will allow reviewers to make ideas based on their knowledge (Dilman, 2007). There were some ideas to improve the questionnaire form and phrasing. These recommendations helped enhance the questionnaire.

• Second, a pilot study was conducted to test the questionnaire's reliability in real-world scenarios. The pilot study included Northern Cyprus undergraduate students.

Also, 102 responses were collected, but only 92 were used to test the questionnaire due to missing data in 10. Dilman (2007) suggested a pilot research sample size of 100-200. The pilot study's measurement items passed the Cronbach's alpha test. Finally, a new PhD researcher reviewed the questionnaire to increase the likelihood of spotting obvious errors (Dilman, 2007).

4.5.2 Administration of Questionnaires and Ethical Considerations

The survey was sent to Northern Cyprus residents. The questionnaire was also approved by the university's ethics board. The application linked to the questionnaire and described the research goal. After six weeks of data collecting, the questionnaire link was closed. This study followed EMU's Ethical Code of conduct on research. The Ethical form for the research was signed and handed over to the Research Graduate Institute. There was no request for personal information such as name, phone number, or email address. A completion of the survey indicated consent to participate in the study. Finally, all participant information was kept strictly secret and used only for this study.

4.6 Data Processing

The research data was examined using the SEM technique including multiple regression, CFA, and multivariate analysis of variance which are all multivariate techniques. SEM is also a multivariate technique that allows “to simultaneously examine a series of interrelated dependence relationships” between measured variables and constructs. Although SEMs use two multivariate approaches, CFA and multiple regression, they have four different features (Hair et al., 2010). Calculate interdependent dependency relationships first. Second, represent unknown variables. Third, consider measurement error. Finally, build a relationship model. SEM is also useful for assessing theories involving dependency (Hair et al., 2010). SEM is enabled

by two well-known statistical software packages: AMOS and SMARTPLS. SMARTPLS was used for confirmatory factor analysis and multiple regression in this investigation. The software generates regression paths between independent and dependent variables. This study will use confirmatory factor analysis and multiple regression. In this case, the confirmatory factor analysis determines how effectively the measured variables are represented. The investigation will also give model fit indicators, allowing the postulated theories to be either accepted or rejected based on the results. Second, using the model structure, multiple regression analysis will explain student acceptance variance through perceived utility, perceived ease of use, and behavioral intention. The investigation will also examine the impact of external variables on student admission. The data were screened using SPSS before utilizing SMARTPLS for SEM (for example, missing data).

Chapter 5

DATA ANALYSIS

The analysis of the model and hypotheses are presented in this chapter. The study's statistical analysis was done using SmartPLS and SPSS. Statistical analysis has three steps. The initial step is to clean the data, use the data and test the data. Data screening checks for invalid data, outliers, normality and so on. In the second step, CFA is performed to assess the model measures. The measurements of the developed model define the correlation between observed measured variables and produced model variables. CFA helps assess the model's fit and construct validity. Third, multiple regression analysis is used to test the model and research assumptions. The model specifies the interrelationships offered by the study hypotheses. To identify accepted or rejected hypotheses, the explained variance for the created model will be determined using multiple regression.

5.1 Data Screening

Missing data, outliers, linearity, and normalcy issues may all be present in raw data. As a result, the collected data will be validated.

5.1.1 Sorting Missing Data

When an answer is not generated by the respondent in the questionnaire, missing data occurs (Hair et al., 2010). The process of sorting the obtained data revealed that there were 77 uncompleted responses among the 337 total responses. Seventy percent of the data in these 77 responses is missing, implying that 77 people didn’t answer more than half of the survey questions. A response should be eliminated if it fails to address 50

percent of the questionnaire's questions (Hair et al, 2010). To avoid generating any false association between the model variables, the 77 uncompleted replies were removed in this case.

5.1.2 Descriptive Statistical Analysis

After deleting the missing data, there were a total of 260 completed responses. For the statistical analysis, all 260 completed replies were considered. The descriptive statistical analysis of the 260 gathered data are shown in Tables 5-1 - 5-3.

Table 5.1: Descriptive analysis for gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MALE	131	50.4	50.4	50.4
	FEMALE	129	49.6	49.6	100.0
	Total	260	100.0	100.0	

Table 5.2: Descriptive analysis for title

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	WORKER	132	50.8	50.8	50.8
	STUDENT	128	49.2	49.2	100.0
	Total	260	100.0	100.0	

Table 5.3: Descriptive analysis for age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-24	88	33.8	33.8	33.8
	24-30	85	32.7	32.7	66.5

	30-40 n Above	87	33.5	33.5	100.0
	Total	260	100.0	100.0	

5.2 Model Analysis Results

A minimum value of 0.7 was required for the latent variables to be regarded acceptable according to the Composite reliability and convergent validity (Henseler et al., 2014). Table 5.4 shows that the measuring model's results meet these conditions. Composite reliability and Cronbach's Alpha both exceed the aforementioned target according to (Nunnally, 1978), while the AVE value exceeds the value of 0.5 according to (Straub et al., 2004)

Table 5.4: Composite reliability and convergent validity.

	"Cronbach's Alpha"	"Composite Reliability"	"Average Variance Extracted" (AVE)
AU	**0.859**	**0.914**	**0.781**
BI	**0.857**	**0.933**	**0.875**
PC_	**0.835**	**0.901**	**0.753**
PEOU	**0.722**	**0.822**	**0.607**
PR	**0.712**	**0.840**	**0.637**
PU_	**0.845**	**0.928**	**0.865**
TRU	**0.875**	**0.941**	**0.889**

Table 5.5 shows the model's and constructs' discriminating validity. This test compares the square root of each latent variable's AVE to the square root of all other variables (Ringle, Sarstedt, and Straub, 2012). (Barclay, Thompson & Higgins, 1995).

Table 5.5: Fornell-Larcker criterion.

	AU	BI	PC_	PEOU	PR	PU_	TRU
AU	0.883						

BI	0.561	0.935					
PC_	0.539	0.473	0.868				
PEOU	0.678	0.393	0.477	0.779			
PR	0.484	0.362	0.513	0.435	0.798		
PU_	0.513	0.783	0.407	0.394	0.380	0.930	
TRU	0.285	0.274	0.238	0.249	0.617	0.238	0.943

The values utilized to evaluate the structural model using the path coefficients are shown in Table 5.6. To determine whether correlations were significant, researchers utilized the bootstrapping resampling technique with 5000 test cycles.

Table 5.6: Structural model test (path coefficients).

	"Original Sample" (O)	**"T Statistics"**	**"P Values"**
AU -> BI	0.170	3.404	**0.001**
PC_ -> BI	0.146	2.976	**0.003**
PEOU -> AU	0.563	11.569	**0.000**
PEOU -> PU_	0.394	7.485	**0.000**
PR -> BI	-0.105	2.206	**0.027**
PU_ -> AU	0.291	5.468	**0.000**
PU_ -> BI	0.652	13.372	**0.000**
TRU -> BI	0.100	2.175	**0.030**

Table 5.7 shows some of the indirect effects of the links between the primary components.

Table 5.7: Total indirect effect

	"Original Sample" (O)	**"T Statistics"**	**"P Values"**
PEOU -> AU	0.115	4.532	**0.000**
PEOU -> BI	0.372	7.135	**0.000**
PU_ -> BI	0.049	2.873	**0.004**

According to the model's results, it can explain a lot. Table 5.8 shows the values compiled for R-squared, specifically BI. Both the R-squared and the adjusted R-squared were more than 0.1 according to (Falk & Miller, 1992). For example, Chin says a score of 0.67 means strong explanatory power, 0.33 means moderate, and 0.19 is weak (1998). Table 5.8 reveals that all of the variables except Perceived Risk (R-squared = 1.000) are significantly greater than the minimum level, showing considerable indicatory power.

Table 5.8: R-squared values for the model.

	"R Square"	**"R Square Adjusted"**
AU	0.531	0.527
BI	0.664	0.657
PU_	0.155	0.152

The assessment of the model's fit was carried out using the Standardized Root Mean Square Residual (SRMR), which came in at 0.076, just under the suggested limit of 0.08 (Henseler et al, 2014). For the final evaluation, the model's Stone-Geisser represent as Q2 in the table below (Gefen, Rigdon & Straub, 2011) values were used. Q2 values shows predictive power as they were greater than zero (Roldán & Sánchez-Franco, 2012). Table 5.9 shows the outcomes.

Table 5.9: Predictive power of latent variables**.**

	SSO	**SSE**	**Q^2 (=1-SSE/SSO)**
AU	780.000	463.520	0.406
BI	520.000	226.509	0.564
PU_	520.000	452.320	0.130

Figure 5 presents the data model with the tested hypothesis' indications. The original coefficient, structural model p-values, and significance between independent and dependent constructs were all examined. Figure 4 depicts the many links between the adopted constructs. As seen, all constructs had a favorable relationship. Hypothesis testing was utilized to explore the multiple links. Table 5.4 to 5.8 summarizes the findings.

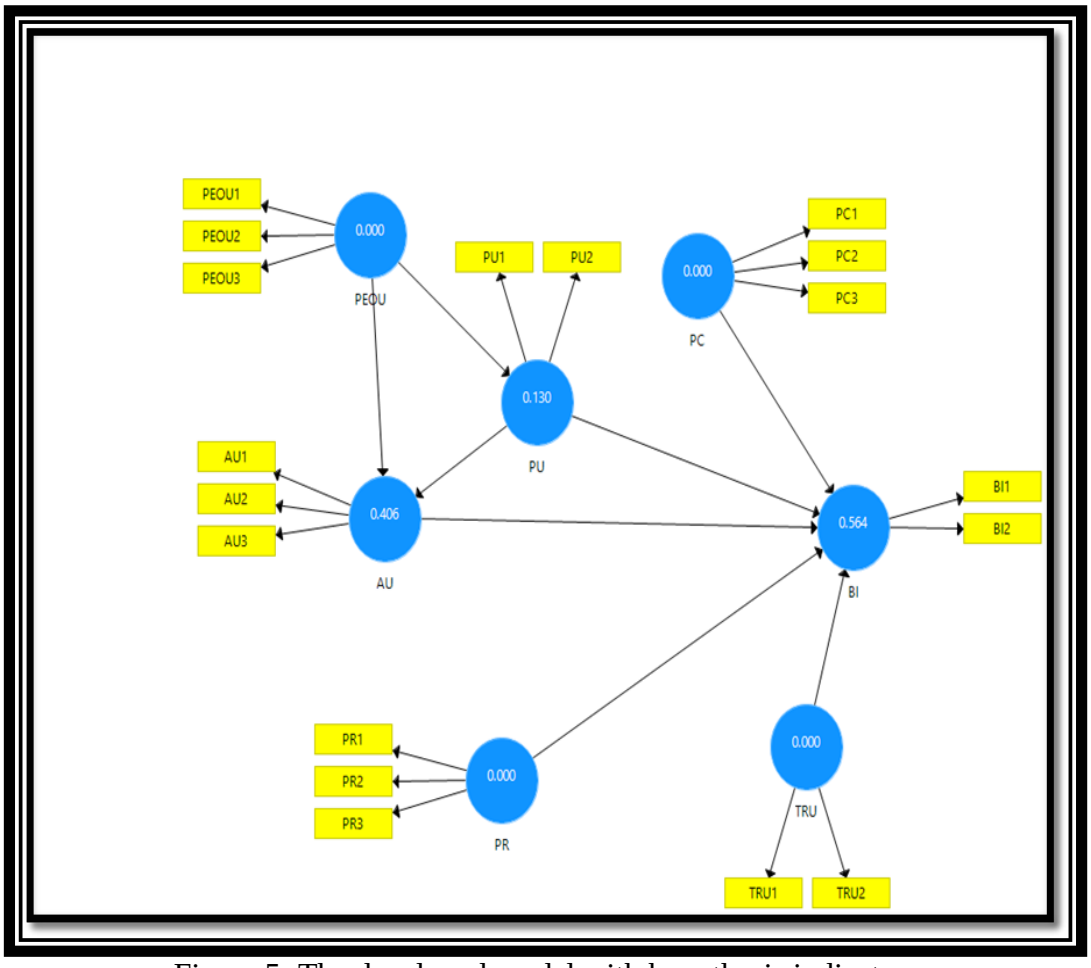

Figure 5: The developed model with hypothesis indicators.

Chapter 6

DISCUSSION AND CONCLUSIONS

Extending the TAM model is considered useful for evaluating intention to use an application, which in this example is a contact tracing application that alert those who have come into contact with a proven COVID positive individual, thereby assisting in containing the disease's further spread. The theories postulated for this research were verified including the modified model with extra variables also has a higher predictive potential. The biggest factor loadings are for H1 AT -> BI (β= 0.170; t = 3.404), H4 PEOU -> PU (β = 0.394; t = 7.485), and H5 PU -> AT (β = 0.291; t = 5.468). H3 PEOU -> AT (β = 0.563; t = 11.569) and H6 PU -> BI (β = 0.652; t = 13.372) are also included in the original TAM model. According to the research, they have a confidence level of higher than 95%. As an outcome, the theoretical TAM model may be used to forecast app adoption in order to avoid or mitigate the impacts of the COVID-19 pandemic.

The model's most significant variables are PEOU (β = 0.563; t = 11.569) and PU (β = 0.652; t = 13.372), followed by AT (β = 0.291; t = 5.468). These findings corroborate findings from a recent study that employed the enlarged TAM model.

With a confidence level of greater than 99.9 percent, H8 (β = 0.170; t = 3.404) was the correlation for the additional factor that had a direct effect on BI to Use. This demonstrates that the user of the application holds on to trust in the fact that the

application will keep its promises, satisfy their expectations, and take into account the requirements of individuals as citizens and community members. These three elements significantly influence the desire to use the application in everyday aspect of life.

Following that, the extended constructs or variables incorporated into the standard TAM model were analyzed for this study. In H2, the constructs or variables were combined to provide the PR-> BI ($\beta = 0.105$; $t = 2.206$) value. The connection was established with a degree of conviction better than 99.9 percent. As can be seen, users' anxieties of contracting COVID-19 or having family members contract it significantly influence their decision to utilize the application. Additionally, users are concerned about contracting COVID-19. These worries, along with a sense of vulnerability and information about the high frequencies of COVID-19 transmission, have a substantial impact on the motivation to test and use this app on a regular basis in the future.

The final external variable in the model, PC, was insignificant and had a 95% conviction level. As a consequence, H7 PC -> BI ($\beta = 0.046$; $t = 0.976$) was not significantly different from zero. This indicates that fear of data being exploited in the app, such as other people using personal information in unanticipated ways, has no detrimental effect on the willingness to try out and use the app on a regular basis later on. This result has been observed in previous research on app adoption models and is described in the literature (Palos-Sanchez, Correia & Saura, 2019).

Trust is the most influential extension variable on the customer's selection, followed by PR of being exposed to the disease. In both cases, the greater the perceived threat and the higher the level of trust, the greater the urge to utilize the app. It's worth noting the Behavioral Intention to Use model's outstanding explanatory power ($R2 = 0.664$),

as well as its predictive capability (Q2 = 0.564), when combined with additional variables such as AT (R2 = 0.531) and PU (R2 = 0.155).

6.1 Theoretical Conclusions

Using an extended TAM model, the use of data systems and geolocation technologies to oppose the main viral method of transmission, which involves persons under two meters away. The focus on privacy is the most unusual component of this study. While the data privacy of contact tracing apps themselves was emphasized by other researchers (Liu et al., 2020), or by the ways in which privacy is being protected by people (Yasaka, Lehrich, & Sahyouni, 2020), the results of this study show that people are unconcerned about privacy with regard to medical issues. We introduced a new variable to the TAM for the first time: the perceived risk of COVID-19 infection. It had a big effect on the explanatory power of the TAM.

6.2 Applicable Conclusions

The global pandemic has seen lots of individuals affected and a substantial amount of deaths due to the 19th century virus spread. Because many countries have embraced strange containment measures, healthcare services may focus on the sick. As a result of this restraint, the international economy has suffered an unprecedented setback. Because of this, individuals and advocacy groups are demanding more expeditious mechanisms for de-escalation. Health officials must find and trace prospective contacts of those with health issues who may need to relocate in order to restart the economy. Various techniques have been proposed for this tracking, including phone applications (Li & Guo, 2020).

Despite the necessity of shifting the balance of health and quality of life in favor of the former, the industry has suffered. Employing tracking technology should be used for

the sole purpose of guaranteeing safety for the occupants in a country and the ability to identify new, positive individuals and their contacts in the de-escalation process.

Countries like South Korea have been able to use this technology to calm tensions and re-energize their economy. As per (Porter and Donthu 2006) and (Kucukusta et al. 2015), users' usage intentions for this app are impacted by how valuable they think it is, and privacy is no longer a major worry (Madyatmadja, Nindito & Pristinella, 2019). People will usually choose health over privacy when they are given the option.

Geolocation applications are likely to benefit from this research, as are governments that must determine whether or not to use geolocation, and the dangers that this represents for the privacy of citizens. The independence and freedom of Europeans has never been under this much duress, or been imperiled in this manner, before. It may be quite advantageous for officials to discover that individuals over the age of 30 are really worried about infecting themselves or their loved ones, and that this has a notable effect on their interest in downloading the app. The user's awareness of vulnerability to infection from the virus also influences their purpose. The dread of the pandemic infection, including the feeling of being vulnerable, greatly impacts the desire to utilize the app. The results of the present study are consistent with the findings of prior research (Abeler et al., 2020), which revealed that three quarters of UK respondents would use the app. In four major European countries, these authors found significant acceptance for the type of app examined in this study, signaling the feasibility of a pan-European application with roaming data across borders. The app's launch must be dealt with promptly, and time cannot be wasted. First and first, users must think it is an effective measure (especially for people with high knowledge levels), that it is easy to use, that it respects data, and, most importantly, that it doesn't

cause privacy concerns. If working people trust the application and if it's helpful, polite, and easy-to-use design, they would be more likely to utilize it, according to this study.

6.3 Limitations and Future Research

The research has presented some interesting results to explain what influences users to use contact tracing applications. However, certain limitations in this study could have influenced the results of the research analysis conducted.

The research population was low for this study due to the restrictions and other control measures that have been enforced by the Government which means that the self-selection method used in the survey distribution process was inadequate. Also, the research population largely comprises of student studying in the country and a small amount of the main citizens of the country which means that on could use the word "residents" when generalizing users. Time was also a limitation in this study as the participants was lower than the expected amount. This has a relation with the first aforementioned limitation. For future research, a large amount of population is required for this study. One could further develop the system and data model used in this research as a change to the system model will require a change in the data model. A more detailed plan could also be made if there is plan to implement such system developed in this study. Such plan should detail extensively who runs the system and the requirements needed in order to make it more efficient.

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APPENDICES

Appendix A: Questionnaire Developed for Study

Technology Acceptance Model Perceived usefulness (PU)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. The retrace app for contact tracing will allow me get useful information about covid19 in Northern-Cyprus					
2. Using the retrace mobile app will increase the efficiency of contact tracing in Northern Cyprus.					

Technology Acceptance Model Perceived ease of use (PEOU)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Learning to operate the retrace app for contact tracing would be easy for me					
2. Without any guide or prior knowledge, I find the retrace app features to be flexible to interact with.					
3. It would be very easy for me to become skilful at using the retrace app for contact tracing.					

Technology Acceptance Model Behavioral Intention (BI)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I feel very confident in using the retrace app for contact tracing in Northern-Cyprus					
2. I can move around with more ease having the retrace app installed on my phone.					

Technology Acceptance Model Attribute of usability (AU)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I think that I'd like to use this mobile app always.					
2. I find that the functionalities in the mobile app suits my lifestyle in Northern Cyprus.					
3. It is easy to retrace crowded places and my daily activities, when using this app					

Technology Acceptance Model Privacy Concern (PC)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I am concerned that information from the APP may be used inappropriately					
2. I am concerned that someone else may find out private information about me.					
3. I am concerned that the information provided to the App may be used by other persons or companies					

Technology Acceptance Model Trust (TRU)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. This App gives me confidence					
2. This App would take into account the interests of its residents.					

Technology Acceptance Model Perceived Risks (PR)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I think the chances of us getting infected with COVID-19 are very high					
2. I feel that we may be vulnerable to COVID-19 infection					
3. I am worried about getting infected or my family members getting infected with COVID-19					

Appendix B: Approval from the Ethics Commitee

Doğu Akdeniz Üniversitesi
"Erdem, Bilgi, Gelişim"

Eastern Mediterranean University
"Virtue, Knowledge, Advancement"

Galileo Galilei Sk. / Str.,
99628, Gazimağusa, KUZEY KIBRIS /
Famagusta, NORTH CYPRUS,
via Mersin 10, TURKEY
Tel: (+90) 392 630 1327
bayek@emu.edu.tr

Bilimsel Araştırma ve Yayın Etiği Kurulu (BAYEK) / Board of Scientific Research and Publication Ethics

Reference No: ETK00-2021-0167 04.06.2021

Subject: Your application for ethical approval.

Re: Jeremiah Damilola Adebiyi (19500271)
The School of Computing and Technology

EMU's Scientific Research and Publication Ethics Board (BAYEK) has approved the decision of the Ethics Board of SCT (date: 03.06.2021, issue: 03) granting Jeremiah Damilola Adebiyi from the The School of Computing and Technology to pursue his MA thesis titled **"Determinants of the intention to use the contact tracing apps: A case studt in North -Cyprus"** supervised by Asst. Prof. Dr. Mustafa Babagil

Best Regards

Prof. Dr. Yücel Vural

Chair, Board of Scientific Research and Publication Ethics - EMU

YV/şk.

www.emu.edu.tr

Appendix C: Consent Form for Survey Participants

Jeremiah Damilola Adebiyi

MSc Information Technology

05338529621

Jeremiah.adebiyi@emu.edu.tr

CONCENT FORM

Dear Participants,

I am an MSc student conducting my thesis on the "DETERMINANTS OF INTENTION TO USE THE CONTACT TRACING APPS: A CASE STUDY IN NORTH-CYPPRUS".

Please answer all the questions sincerely and be informed that your personal information and individual responses will be kept confidential and used only for research purposes. Collected Data can be used for future publications. For more information, please feel free to contact me or my MSc thesis supervisor. Participating in this study is on the voluntary bases and you are free to withdraw from the study at any time. If you agree to participate, please fill the space provided below and sign it.

Jeremiah Damilola Adebiyi
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Asst. Prof. Dr. Alper Doganalp
School of Computing and Technology,
Eastern Mediterranean University (EMU)
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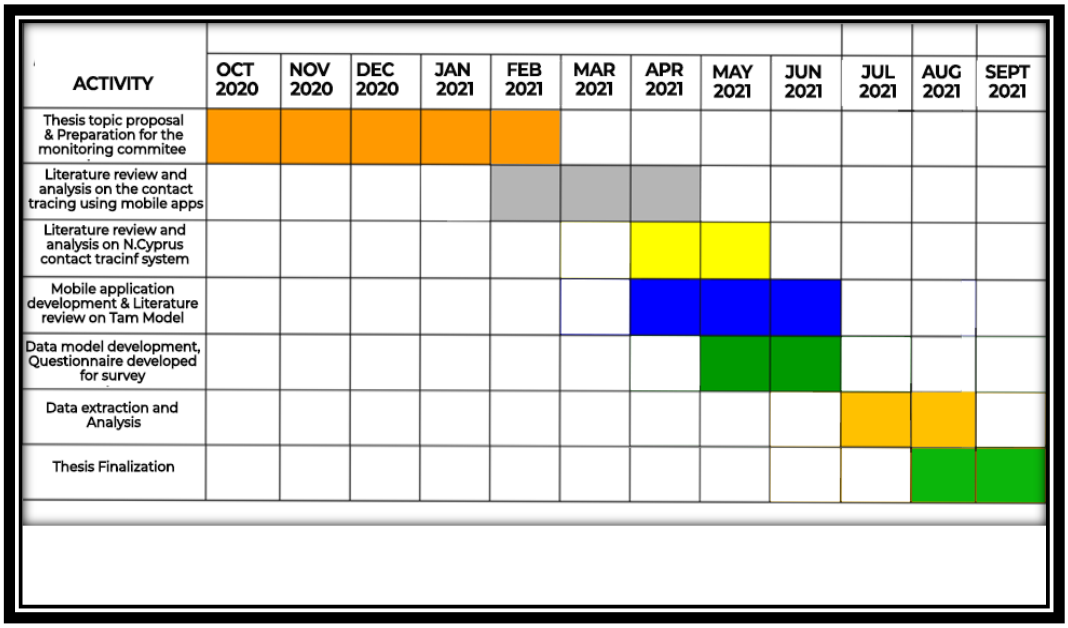
I have been properly informed about the objectives of the study and I agree to take part in it.

Name-Surname: _____Jeremiah Damilola Adebiyi_____

Data: _____03/6/2021_____

Signature:_____Jeremiah Damilola Adebiyi_____

Appendix D: Timeline of Study



Determinants of Intention to use the Contact Tracing Apps: A Case Study in North-Cyprus

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