Teleconsultation Apps in the COVID-19 Pandemic: The Case of Guayaquil City, Ecuador

—Bryan Pérez-Noboa
Faculty of Electrical and Computer Engineering, Escuela Superior Politécnica del Litoral, Guayaquil, EC090603, Ecuador

—Aldair Soledispa-Carrasco
Faculty of Electrical and Computer Engineering, Escuela Superior Politécnica del Litoral, Guayaquil, EC090603, Ecuador

—V. Sanchez Padilla
Faculty of Electrical and Computer Engineering, Escuela Superior Politécnica del Litoral, Guayaquil, EC090603, Ecuador

Member, IEEE

—Washington Velasquez
Faculty of Electrical and Computer Engineering, Escuela Superior Politécnica del Litoral, Guayaquil, EC090603, Ecuador

Member, IEEE

(Corresponding author: V. Sanchez Padilla.)

IEEE DOI 10.1109/EMR.2021.3052928

***Abstract*—*The new coronavirus disease (COVID-19) has affected a large part of the worldwide population, causing more than a million deaths between the end of 2019 until now. Technological development and digital tools arise to carry out activities remotely, either for monitoring or diagnosis. Medical teleconsultation activities are not new, but due to the pandemic situation that the COVID-19 originated, it has become a popular option to avoid going to consultations physically due to the risk of contagion. This article presents an analysis of different teleconsultation services implemented during the spread of the COVID-19 in the city of Guayaquil, Ecuador, as a case study. The methodology includes a performance assessment of the teleconsultation apps used during the critical periods of the pandemic. We detailed the fundamental stages deemed to verify that the fulfillment and knowledge about telemedicine in this city are not extensive enough in terms of remote health benefits. Throughout this article, we evidenced that the population is not prepared to manage remote-care systems due to the low use of technology and the lack of support from public or private agencies for providing technological development for medical services that satisfy the needs of the inhabitants.*

Key words: Health technology, remote-care management, sustainability, telemedicine apps, virtual care

I. Introduction

TELEMEDICINE allows accessibility in the daily health practices of physicians that are far away from medical facilities, as well as the establishment of novelty care schemes. Through its implementation, it is possible to assist chronic patients or to provide reliable monitoring. Among its features, highlight the readiness, mobility, and confidentiality [1], [2]. For instance, a study carried out in Bangladesh depicted that 75% of its rural population cannot access optimal health conditions, whereas urban zones have more assets to provide medical attention. Patients stated that hospitals did not have the complete resources or enough staff to provide total assistance in specific areas [3]. The Okola health district in Cameroon evidenced a similar scenario, where the rural areas lack the specialized personnel to provide health care to the population. Several factors influenced it, such as the lack of incentives from government entities, or the fact that medical professionals have to leave their homes for long periods. These aspects discourage them from moving to remote areas, having equal or better benefits if they stay in urban areas [4].

Remote medical attention is not new. It comes since ancient times, where physicians communicated with their patients or assistants through intermediary techniques, such as smoke signals and light reflections. More recently, long-distance mailing was useful to inform about news

regarding the health condition of a patient or group. The telegraph and telephone gradually replaced it [5]. Nowadays, multiple technologies allow physicians to approach patients located at long distances by remote options or through calls using phone devices for interactive clinical consultations [6] or using data networks for real-time consultation complemented with storage and accessibility options [5].

Another term that comes to light is telehealth, which deploys telecommunications and information technologies for access to health information and services related across a geographic area [7]. Through telemedicine, physicians can follow-up treatments remotely, monitor patients through sensor systems, or carry out surgery procedures using robotic arms [8]. These aspects turn it into a feasible solution and lead to the automation in health practices to avoid the presence in medical facilities, where people can be exposed to viruses and bacteria, which in subsequent can produce time loss, money expenditures, and personal setbacks [8], [9].

Around the world, hospitals implement virtual care to prevent patients from contagion [10]. This method tried to reduce the Coronavirus disease (COVID-19) cases for preserving the physical and mental integrity of the staff with the introduction of telemedicine especially in locations where is more difficult to access due to geographical features and environmental conditions. Although there are several drawbacks, such as the lack of knowledge in the use of new technologies or infrastructure, plus the high costs in communication network services [11], it is necessary to evaluate the results of these implementations to take corrective actions or change healthcare policies [12].

Even though telemedicine is a useful resource for real-time monitoring of diseases, it is not possible to implement it on large scales in different scenarios due to the technological infrastructure it demands. This problem arises mainly in rural areas, where not all the inhabitants of a community have a smartphone or tablet with mobile connectivity for remote diagnosis or treatments. Tran *et al.* [13] present the case on how telemedicine is not integrated into the Vietnamese health care system because of a lack of strategies, assets, infrastructure, and regulations, among others. In this case, to overcome the potential spread of the virus, diagnosis and treatment processes were oriented to a strong social distancing. As this case presents, is sort of difficult to assist areas composed of several ethnic groups, where the population using mobile technologies do not necessarily have available smartphones or similar devices. In addition, like many countries worldwide before the COVID-19, telemedicine approached technical and infrastructure aspects instead of medical education and manners to empathize the relation between health professionals and patients.

The main contribution of this article is to analyze the use of teleconsultation apps during the COVID-19 pandemic. The methodology includes surveys carried out to app users and staff from public and private health institutions from Guayaquil, a coastal city of Ecuador. The need to provide more impact on telemedicine services and deploy technological resources for remote communication systems aims to realize if the population feels more confident to change their perception regarding ongoing technologies.

The rest of the article has the following structure. Section II describes the state of the art of advantages regarding telemedicine and the quarantine process experienced by the country during the first months of 2020. Section III describes the methodology of the study to define the consultation models, different stakeholders, and the necessary sampling for its implementation in the city of Guayaquil. Section IV presents an analysis of the results obtained from the surveys of physicians and the general public, regarding questions aimed to know the apps used during the pandemic and the level of satisfaction they provide. Then, Section V shows a proposal for virtual medical attention based on a distributed architecture scheme according to the needs of the population. Finally, Section VI presents conclusions of the results obtained and the feasibility of implementing teleconsultation across the country.

II. State of the Art

At the end of 2019, in the city of Wuhan, China, the COVID-19 outbroke and spread very quickly around the globe, becoming a global pandemic very dangerous for mankind, infecting almost 15 million of human beings worldwide, mostly due to a continuous transmission among people [14]. Because of this disease, people experience symptoms of pneumonia with a diffuse alveolar lesion, which led to acute respiratory distress syndrome [15]. Although many countries undergo substantial impacts due to the pandemic, especially in the health, daily activities, and conditions of their inhabitants [16], studies like [17] present that the magnitude of depression, stress, and anxiety is low, opposite to the common opinion about the COVID-19 pandemic confinement. This case states that these initial signs of anxiety, stress, and depression in the population, based on different metrics, can be useful for predicting long-term psychological impact.

On the other hand, Hao *et al.* [18] present an assessment and

comparison of stress and psychological impact experienced by people in strictly lockdown measures either having or not psychiatric illnesses. The methodology consisted of a survey managed via SMS to psychiatric patients in a hospital from China. The authors confirm the severity of the negative psychological impact and risks on psychiatric patients during the lockdown due to the COVID-19, where plenty of studies are necessary to develop, turning imperative a more understanding of patients with a continuous psychiatric intervention throughout the pandemic.

Due to the significant risks of contagion, mainly for visiting medical facilities [19], several countries ran drastic confinement actions, which led to new security procedures using technology to avoid people from leaving their homes and being exposed to an eventual contagion. Thus, home delivery alternatives or remote communication services had exponential growth, aiming to a social, labor, or health scopes [20]. Additionally, the environment also face direct and indirect effects. A contingency for the improvement of the quality ecosystem is sought, such as a decrease in air pollution, contamination on beaches, and environmental noise. There are secondary aspects that have negative impacts as well, reflecting the reduction in recycling and the increase in waste in physical spaces [21].

Ecuador, a country located in the South Pacific of the American continent, registered the first case of COVID-19 on February 29, 2020, collapsing the health, political, economic, and social systems. This country records approximately 226 900 cumulative cases and more than 14 270 total deaths until the mid of January 2021 [22]. Since the government established quarantine, several solutions arose, such as the increase in the use of delivery apps, online banking transactions, teleworking, remote health consultations, in order to adapt the majority of the population to the scheme provided by the new reality.

In the second week of March 2020, the Ecuadorian Ministry of Health declared a state of emergency in the national health system. Then, at the end of April, the social distancing stage started based on traffic light system across the national territory [23], [24]. The change of the traffic light must be taken into account depending on the contagion that exists in each city, e.g., cities with red traffic lights must respect a curfew: from 2:00 P.M. to 5:00 A.M., with vehicular circulation restricted to one day per week. In May, the mayor's office of Guayaquil had to take preventive actions after 33% of the residents turned infected. Of this percentage, 14.8% exceeded 14 days of infection, moving to the final phase of the disease [25].

Actions to prevent the spread of the virus were established in Ecuador and worldwide [26], [27], which aimed to the compulsory teleworking, modification of working hours, the shutdown of educational institutions, crossing border restrictions, suspension of mass events, domestic quarantine, vehicular mobility restriction between cities, and limitation into public places [12], [28]. For instance, the Ecuadorian government promoted the use of home delivery apps for the purchase of medical and food supplies [29]. Other governments use these alternatives to prevent the population from being exposed to potential viral risk. The services focus on people who have reduced mobility (e.g., people with terminal illnesses) or patients with economic limitations for traveling to food centers [30].

Medical services had to adapt to the problems of the pandemic by improving their viral exposure control protocols. The most feasible solution for society is the use of telemedicine, which prevents people from visiting health centers, even when they only experience mild discomfort [19], [31]. Moreover, virtual consultation services boosted exponentially by the high demand for medical attention because of COVID-19, increasing the confidence of the patients in healthcare systems and avoiding unnecessary traveling of both physicians and patients [32]. Throughout history, technology has made possible the communication between people, allowing them to share information efficiently to provide quality care [33].

The teleconsultation allows remote care, health recommendations, assisting nonspecialist physicians in rural areas, among many other options that facilitate regular medical practices [34], [35]. When medical doctors carry out teleconsultations, they may present problems in which they cannot either assess the vital signs of the patients or have real data at the time of doing live consultations to estimate the appropriate treatments. Sensors are positioned in a specific part of the body for a continuous update of health information to know about the status of a patient [36]. For example, if a treatment consists of 30 min per day of jogging, the physician will verify the accomplishment of the recommendations without the need for personal surveillance [8].

Several technological advances allow establishing teleconsultation beyond apps. Different countries create extensive communication networks, in which the medic from either the same or different hospitals can share information about patients. When carrying out a telemonitoring session, it provides a unique experience to the patient. Also, medics can refer to specialists for supplementary consultation. Through official

networks, it is possible to have several specialists at the same time verifying the health of patients [8]. A case to mention is the designated hospital for the diagnosis and treatment of COVID-19 in the province of Zhejiang, China, which uses robots for the care and monitoring of the vital signs of patients, with a system that allows the physician to verify news in real time [37].

The virtual consultation has several limitations regarding communication tools or the taking of physical samples from patients. Using them, it is possible to carry out an analysis of different symptoms presented by patients to indicate whether they must go to a health center. The warmth and empathy between physicians and patients can be affected by the constant use of technology tools due to the lack of human relationships [33]. The population needed to stay in their homes, thus the promotion of teleconsultation services with considerable emphasis by the Ecuadorian Government enabling the 171 telephone line for referrals from the public health system [38].

On the other side, medical experts promote the use of messaging and digital video applications, especially to manage heart complications, diabetes, or asthma [39]. There are also digital tools that allow to search for physicians according to the specialty required. However, it is necessary to have a result analysis of the situation of the teleconsultation apps due to the number they represent. Surveys oriented to health professionals and the general population let us know the satisfaction of users with the use of apps to design an application scheme to meet the needs of patients and medical doctors in a post-COVID-19 era.

III. Methodology

The perception of teleconsultation services had an increase at the beginning of 2020 in the city of Guayaquil. Therefore, it was paramount to carry out a study on the services that help in the prevention of further infections as well as the avoidance of people approaching to health centers. We realized the population preferences regarding teleconsultation apps throughout the different periods of the COVID-19 pandemic.

We carried out survey models through the *Microsoft Forms* platform via social networks and e-mail to a determined population of the city of Guayaquil. The data was gathered anonymously to guarantee the integrity of the information and to effectively show true feelings about the changes that occurred in the year with teleconsultation services. Considering that the respondents may be from different socioeconomic or cultural nature, we can mention the following aspects [34].

- It is necessary to take into account that not every person can use medical virtual services, since children and teenagers must have the supervision of an adult at the time of being carried out to protect their integrity.
- It is necessary to know about technology since tools and services are handled through mobile phones, landlines, or computers.
- People with hearing disabilities must be accompanied by an individual that informs him/her what the physician is consulting or suggesting at the time of the teleconsultation.
- Teleconsultation does not cover treatments that physicians must perform in person. Thus, if a patient needs special treatment, he/she should go directly to the specialist.

Two separate survey models were developed for the general population and physicians to learn about aspects of the teleconsultation in the city of Guayaquil. Not all of the respondents knew about them (the questions for our study are detailed in the Appendix). Therefore, it is unknown if they applied these tools with the public during the pandemic. An in-depth analysis is carried out through a survey in three-time stages with defined questions for each period, i.e., at the beginning of the year (previous), on the current date (ongoing), and for incoming events (further). The description is as follows.

- Previous services stage: the surveys oriented to physicians consisted of ten questions, and for the general population had 13, show the events and results of the teleconsultation services at the beginning of the year.
- Ongoing services stage: the survey consisted of six questions and show the results of the current situation in Guayaquil regarding teleconsultation services during the pandemic.
- Further services stage: the survey for physicians and the general population consisted of seven questions and shows the opinion of citizens respect the teleconsultation services and what they look forward to these services in the future.

The study approaches on the city of Guayaquil, with a population of nearly 2.3 million inhabitants [40]. The use of publications on social networks and e-mails let us gather a random sampling for a posterior tabulation. The statistical equation depicted in (1) based on behavior [41], turned useful to calculate the necessary survey sampling to validate the data with the respective error and confidence value

$$n = \frac{N * Z_{\alpha}^2 * p * q}{d^2 * (N-1) + Z_{\alpha}^2 * p * q} \quad (1)$$

In (1), N represents the total population, Z_{α} equals the value of the normal distribution with the confidence value, p the expected

proportion probability, q the value of $1-p$, and d the error.

To attain a higher percentage of confidence, near to 95%, and the minimum error possible, less than 6%, we required 310 samples considering the amount of the inhabitants of Guayaquil. In the case of physicians, we used 28 samplings from different hospitals and clinics in the city.

IV. Results

The use of telemedicine tools before and during the pandemic was not sufficiently accepted by society. Therefore, the majority of the population gave up its usage, which leads to negative results when asked if they wanted to use telemedicine again in the future. In the case of physicians, they were willing to implement virtual services, but at the present, they would rather maintain face-to-face consultations. In turn, when asked if they would use telemedicine in the future, 50% of them responded yes but with changes in the current options, as shown in Table 1.

It is necessary to take into account the costs that teleconsultation involves since its scope may have will depend on this. The two surveys show that the teleconsultations at the beginning of the pandemic were free of charge since medics understood the situation in the country, the reason why they provided their services for without costs. Prospective users look forward to teleconsultations with costs around $5 to $10, considering that the technology used will be limited due to its low cost. On the other hand, medics deemed their years of study and the current technology, so they stated that it was necessary to charges higher than $15 to carry out the teleconsultations, as shown in Table 2.

Considering that the physicians were in charge of providing teleconsultation, they decided to use apps that were within their reach, which oriented the population to use the same apps. Most of the people use WhatsApp followed by Zoom, as shown in Figure 1.

Mobile phones were the most used devices from the beginning of 2020 until the peak of the pandemic, keeping their popularity nowadays, both for physicians and patients. This situation is because most people have a mobile phone at their disposal. Also, the features of accessibility and mobility allow performing anywhere, as shown in Table 3.

Several technological tools monitor people's vital signs. The most prominent by the population was Samsung Health, which provides information necessary to know if there are health anomalies. On the medical side, there was Health (Huawei), which monitors and verifies the health status of patients, as shown in Figure 2.

When asking the population if they would like to have an app that shows their medical history, 97% answered yes, whereas the rest said no. When asking the same to the physicians, 100% replied yes. Almost everybody expects to have an app that allows the monitoring of clinical history at any time to not depend on unique records storage in hospitals or medical centers, to provide better evaluations and recommendations by the physicians.

Most physicians and patients were satisfied with the virtual services they used during the pandemic. This result does not mean that

Table 1. Use of Telemedicine Tools.

Yes/Not	Populations			Physicians		
	Before	Now	After	Before	Now	After
Yes	26%	14%	39%	61%	39%	46%
Not	74%	86%	61%	39%	61%	54%

Table 2. Teleconsultation Cost Suggested by the Stakeholders.

Cost per service ($)	Populations			Physicians		
	Before	Now	After	Before	Now	After
Free	54%	N/A	0%	53%	N/A	0%
$x < 5$	5%	N/A	13%	0%	N/A	8%
$5 \leq x < 10$	12%	N/A	50%	12%	N/A	15%
$10 \leq x < 15$	15%	N/A	33%	12%	N/A	31%
$x \geq 15$	14%	N/A	4%	23%	N/A	46%

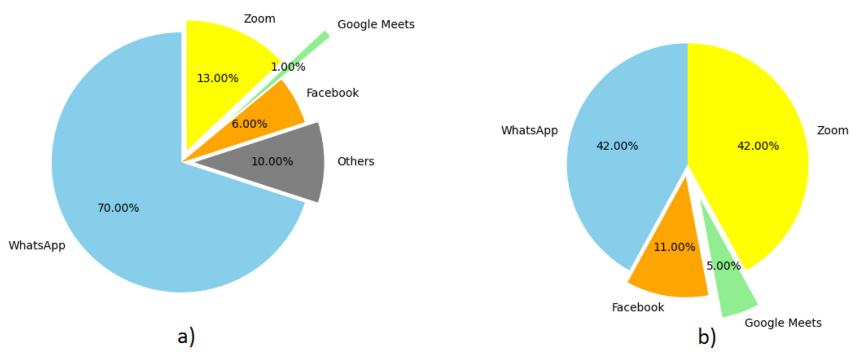

Figure 1. Apps for communication. (a) Population. (b) Physicians.

teleconsultations do not need improvement. Instead, technologies must adapt to the needs of patients and doctors through constant improving, as shown in Figure 3.

V. App Architecture Proposal

The COVID-19 pandemic drastically changed human being's lifestyles. It was compulsory the total confinement of the inhabitants in several cities to keep away from the virus. However, this raised another concern, e.g., how long-term confinement would affect people? (from a psychological perspective). A study was conducted in China to measure several parameters of their citizens. This study asked about the demographic data, physical symptoms in the past 14 days, knowledge and concerns about COVID-19, precautionary measures against COVID-19 in the past 14 days, the psychological impact of the virus outbreak, and mental health status. The results showed that more than 50% of the people surveyed presented moderate or severe psychological indices, 15% had symptoms of depression, 28.8% reported moderate to severe anxiety symptoms, and 8.1% reported certain levels of stress [42].

The survey results obtained in Guayaquil on the use of teleconsultation applications are not far from the reality of the cities in China. Both agree that it is necessary to use telematic methods for these situations. With the survey results and estimating the population needs, it turns essential to develop an app that controls vital signs for different scenarios. It should have the option to set schedule alarms for remembering the medicine that the patient should ingest and his/her current address in case of an emergency. Besides, the app should also have the option to issue a virtual certificate for work incapacity and record the clinical history to provide a better assessment.

The application programing interface (API) user depicted in Figure 4 consists of three layers: data collection, services, and internal registers. The data collection layer consists of a sensor array for continuously monitoring the vital signs of the patients. Meanwhile, the services layer consists of three services to be provided by the app, such as medication alarm service, certificate issuing, and GPS. The first will be responsible for maintaining the schedules and setting the alarms to warn the user of the administration of medications. The second service issues a certificate if the physician considers it necessary. Then, the GPS will pinpoint the user location in case the medic deems a face-to-face assessment. With this, the position of the patient will be available in case an ambulance or rescue service is required. Finally, the internal records layer is responsible for maintaining records related to vital signs, medical history, and geographical position. Based on these records, the physician will have a better view of the patient's health to do a more accurate assessment. This architecture is easily coupled to the era of the COVID-19 pandemic due to the need to track users in real-time (infections), their vital signs, maintain semipersonal (virtual) contact with doctors, even wearables or smartwatches for patients (general public) can function as Internet of Things devices that connect to the

Table 3. Remote Health Monitoring or Diagnostic Device.

Device	Populations			Physicians		
	Before	Now	After	Before	Now	After
Mobile phone	82%	65%	N/A	56%	50%	N/A
Computer	14%	25%	N/A	40%	44%	N/A
Tablet	2%	10%	N/A	4%	6%	N/A
Others	2%	0%	N/A	0%	0%	N/A

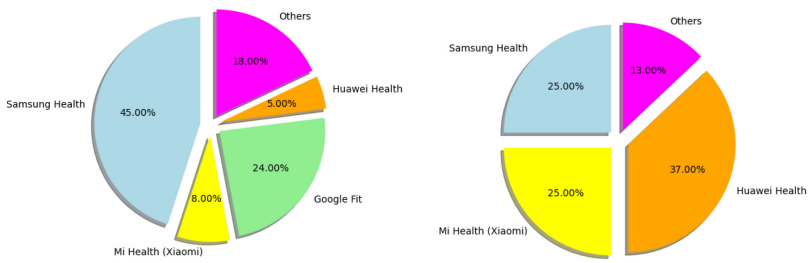

Figure 2. Apps for monitoring vital signs. (a) Population. (b) Physicians.

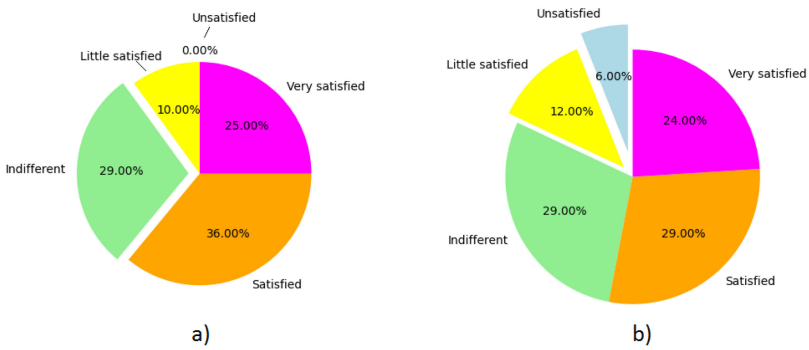

Figure 3. Satisfaction of teleconsultation services during the pandemic. (a) Population. (b) Physicians.

user interface and generate alerts in case of any emergency, e.g., medics can be notified of the increase in temperature of a user and at the same time to instruct the patient to take the necessary measures.

The diagram of the server to be running through Amazon Web Service (AWS) for ease of deployment, performance, and scalability is depicted in Figure 5 (back-end). It consists of four layers: collection, scalability, programming, and presentation. The collection layer receives data from the cloud, which is sent at the moment the user decides to use the application. This layer consists of a route 53 to obtain the domains and classify the received data to store it in an S3 bucket. Next, the scalability layer allows the service to be scalable based on the growth and acceptance of the app. This layer consists of a load balancer to process the large amount of data that can be received. Also, with the use of EC2, it is possible to get cloud capacity with variable size, where the results can be sent to another S3 bucket to store the relevant information. The programming layer will manage the logical part of the server. It consists of an AWS Lambda service to process the information and thus generate the results expected by the administrator. Finally, the presentation layer will provide outcomes graphically and clearly to analyze the different behaviors on time about the communication results between the physician and the patient.

VI. Conclusion

The use of teleconsultation apps in the city of Guayaquil did not have a considerable impact on the population. Despite the different calls from the private clinics and government agencies to adopt them, more than 70% of the people preferred to visit medical facilities instead of using technological tools, which leads to

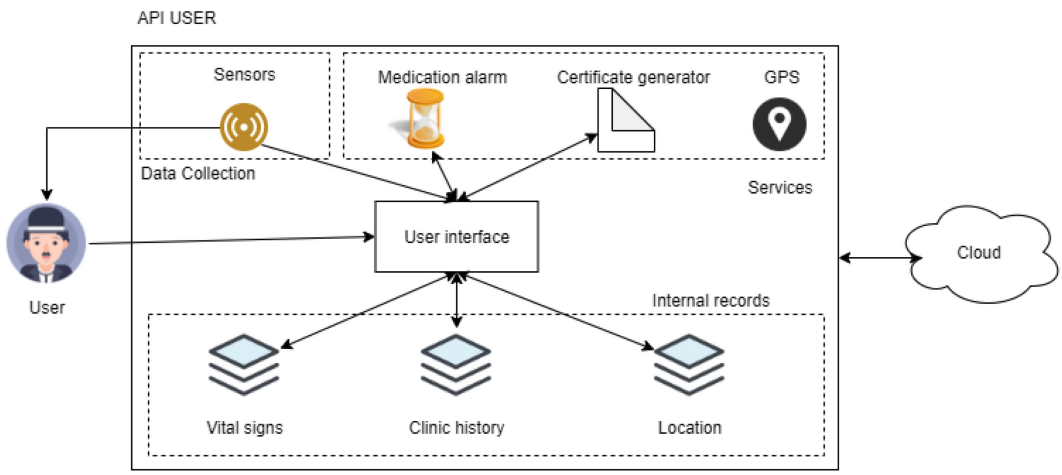

Figure 4. App design for teleconsultation services.

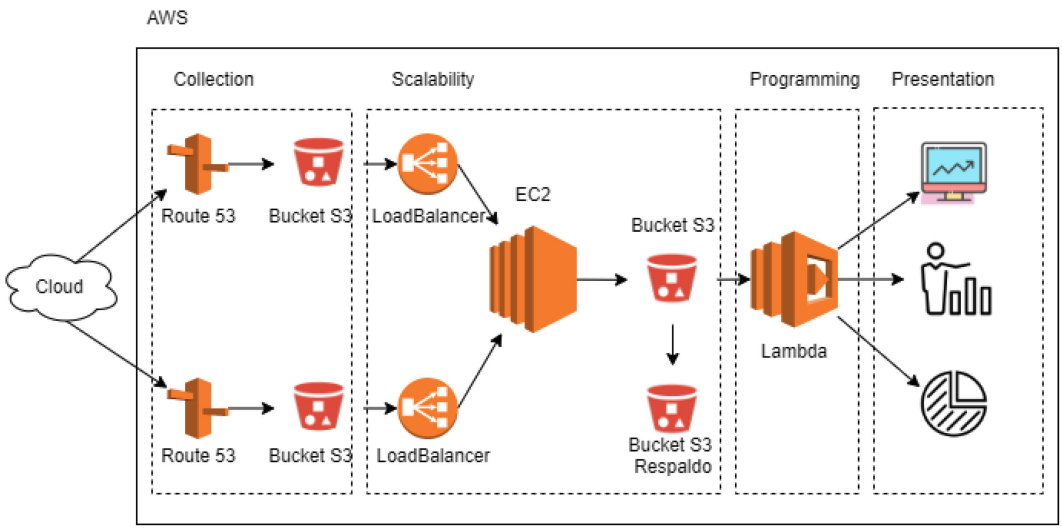

Figure 5. Application server internal diagram.

saturation of health services. In addition, many people were not comfortable or did not know about telemedicine tools, the reason why they preferred to attend medical centers or private appointments even with the risk of contagion. To prevent it, the Ecuadorian government decided to promote teleconsultation sessions through mobile and desktop applications for reducing the rate of infections due to COVID-19.

The surveys depicted that a high percentage of physicians monitored their patients through different apps despite not being virtual-oriented, providing both public and private care from homes or wherever the attention was required. Additionally, based on the results gathered, medics started to use apps, such as Samsung Health, Google Fit, Mi Health (Xiaomi), Apple Health, Huawei Health, mainly because they were within their reach. They also controlled and monitored the health of their patients through video calls made from their mobiles or computers, assuring care and treatment for home emergencies.

Finally, the study shows that due to the lack of knowledge of teleconsultation tools, the population made use of apps oriented to social networks and teleworking mainly on account of the low data rate requirements and the ease in the usage. Because of cultural barriers and technological shortcomings evidenced, an enhancement of the teleconsultation services is necessary, based on a consistent scheme that satisfies the needs of both the population and medical staff.

Appendix
Summary of the Survey Questions

GENERAL INFORMATION

1. Choose your gender.
   - Female
   - Male
   - Other
2. Choose your age range.
   - Under 18.
   - Between 18 - 30 years
   - Between 31 - 50 years
   - Over 50.
3. Mention your residence zone in the city of Guayaquil?

PRE TELE-CONSULTATION SERVICES

4. During the last 3 months, did you use any tool for remote health consultations, monitoring or diagnoses?
   - Yes
   - No
5. To apply to consultations, monitoring or remote health diagnoses, you used:
   - Mobile or desktop applications
   - Phone call to 171 or 911
   - Consultations with hospitals or clinics
   - Direct contact with a medical doctor
   - Other
6. Were you referred to medical doctors from a hospital or clinic?
   - Yes
   - No
7. Mention the name of the hospital or clinic to which the referring physician belongs.
8. Mention the medical facility where the consultations, monitoring or remote health diagnoses were carried out.
9. How much (average) monetary expense that you invested in the consultation?
10. How long (average time) did the remote health consultation, monitoring or diagnosis take?
11. What days are established for consultations, monitoring or remote diagnoses?
12. At what time was established the communication with your medical doctor?
13. If you have used one or more applications to communicate with your doctor, select the application you have used.
    - Facebook
    - Google Meets
    - WhatsApp
    - Zoom
    - Other
14. In which device did you receive remote health consultations, monitoring or diagnose?
    - Computer
    - Tablet
    - Cell phone
    - Other
15. What was your degree of satisfaction with the remote health consultation, monitoring or diagnosis service?
Options from 1 (unsatisfied) to 5 (very satisfied).

1	2	3	4	5
○	○	○	○	○

16. Based on the previous answer, tell us the reason for your qualification.

ONGOING TELE-CONSULTATION SERVICES

17. Do you currently have remote health consultation, monitoring or diagnosis services?
    - Yes
    - No
18. Mention one or more reasons why you do not use remote health consultation, monitoring or diagnosis services.
19. What communication resource do you currently use?
20. In what device do you receive remote health consultations, monitoring or diagnoses?
21. Does your technological device have applications to monitor the health?
    - Yes
    - No
22. Mention the application that monitors your health status. Multiple answers can be chosen:
    - Google fit
    - Samsung Health
    - My health (Xiaomi)
    - Health (Huawei)
    - Others

FUTURE TELE-CONSULTATION SERVICES

23. After the pandemic, would you like to continue using the remote health consultation, monitoring or diagnosis services?
    - Yes
    - No
24. If a mobile device monitors your vital signs, how often would you like it works?
25. Mention how reliable you would find a mobile or desktop application to record your medical history.
Options from 1 (unsatisfied) to 5 (very satisfied).
Considering that at a lower cost, tele-consultation services would be more limited.

1	2	3	4	5
○	○	○	○	○

26. Based on the previous question, please mention the reason for your qualification:
27. Would you like to be able to view your medical history at any time, regardless of the hospital or medical facility ?
    - Yes
    - No
28. How long (average time) would you like the remote health consultation, monitoring or diagnosis to last?
29. How much would you be willing to pay for better teleconsultation services? Considering that at a lower cost, tele-consultation services would be limited.
    - Less than US$ 5
    - Between US$ 5 and US$ 10
    - Between US$ 10 and US$ 15
    - More than US$ 15
30. We appreciate any feedback from you regarding telemedicine services.

REFERENCES

[1] M. Arrese, "Telemedicine, COVID-19 and liver diseases: Revamping remote care initiatives in hepatology," *Ann. Hepatol.*, vol. 19, no. 4, pp. 339–340, 2020.

[2] J. E. Hollander and B. G. Carr, "Virtually perfect? Telemedicine for COVID-19," *New England J. Med.*, vol. 382, no. 18, pp. 1679–1681, 2020.

[3] U. K. Prodhan, M. Z. Rahman, and I. Jahan, "A survey on the telemedicine in Bangladesh," in *Proc. Int. Conf. Comput., Commun. Autom.*, 2016, pp. 857–861.

[4] R.-H. M. Medjo, M. N. Temgoua, M. M. Fouda, and M. M.-J. Essi, "Human resources for health and access to primary health care in rural areas of Cameroon: Case of Okola health district," *Health Sci. Dis.*, vol. 21, no. 4, pp. 122–127, 2020.

[5] H. Shirzadfar and F. Lotfi, "The evolution and transformation of telemedicine," *J. Biosensors Bioelectron.*, vol. 3, pp. 303–306, 2017.

[6] S. W. Strode, S. Gustke, and A. Allen, "Technical and clinical progress in telemedicine," *J. Amer. Med. Assoc.*, vol. 281, no. 12, pp. 1066–1068, 1999.

[7] B. J. Bice-Urbach and T. R. Kratochwill, "Teleconsultation: The use of technology to improve evidence-based practices in rural communities," *J. Sch. Psychol.*, vol. 56, pp. 27–43, 2016.

[8] B. Fong, A. Fong, and C. Li, *Telemedicine Technologies: Information Technologies in Medicine and Telehealth*. Hoboken, NJ, USA: Wiley, 2011.

[9] C.-H. Hsieh, H.-H. Tsai, J.-W. Yin, C.-Y. Chen, J. C.-S. Yang, and S.-F. Jeng, "Teleconsultation with the mobile camera-phone in digital soft-tissue injury: A feasibility study," *Plastic Reconstructive Surg.*, vol. 114, no. 7, pp. 1776–1782, 2004.

[10] L. Schwamm, J. Estrada, A. Erskine, and A. Licurse, "Virtual care: New models of caring for our patients and workforce," *Lancet Digit. Health*, vol. 2, pp. e282–e285, 2020.

[11] D. M. Bolaños, "Telehealth in Ecuador: A world of challenges and opportunities," *La Granja. Revista de Ciencias de la Vida*, vol. 12, no. 2, pp. 32–35, 2010.

[12] R. V. Barragán-Quintero, F. Barragán-Quintero, and E. Ahumada-Tello, "The impact of Covid-19 on innovation: Old projections or new expectations after the pandemic?," *IEEE Eng. Manage. Rev.*, vol. 48, no. 3, pp. 197–201, Sep. 2020.

[13] B. X. Tran *et al.*, "Telemedicine in the Covid-19 pandemic: Motivations for integrated, interconnected, and community-based health delivery in resource-scarce settings?," *Front. Psychiatry*, vol. 11, p. 921, 2020. [Online]. Available: https://www.frontiersin.org/article/10.3389/fpsyt.2020.564452

[14] B. Benreguia, H. Moumen, and M. A. Merzoug, "Tracking Covid-19 by tracking infectious trajectories," *IEEE Access*, vol. 8, pp. 145242–145255, 2020.

[15] M. A. Shereen, S. Khan, A. Kazmi, N. Bashir, and R. Siddique, "Covid-19 infection: Origin, transmission, and characteristics of human coronaviruses," *J. Adv. Res.*, vol. 24, pp. 91–98, 2020.

[16] Q. Liu *et al.*, "An environmental data collection for Covid-19 pandemic research," *Data*, vol. 5, no. 3, pp. 1–13, Aug. 2020. [Online]. Available: http://dx.doi.org/10.3390/data5030068

[17] H. T. Le *et al.*, "Anxiety and depression among people under the nationwide partial lockdown in Vietnam," *Front. Public Health*, vol. 8, pp. 1–8, 2020. [Online]. Available: https://www.frontiersin.org/article/10.3389/fpubh.2020.589359

[18] F. Hao *et al.*, "Do psychiatric patients experience more psychiatric symptoms during Covid-19 pandemic and lockdown? A case-control study with service and research implications for immunopsychiatry," *Brain, Behav., Immunity*, vol. 87, pp. 100–106, 2020. [Online]. Available: https://doi.org/10.1016/j.bbi.2020.04.069

[19] M. Kadir, "Role of telemedicine in healthcare during Covid-19 pandemic in developing countries," *Telehealth Med. Today*, vol. 5, no. 2, pp. 1–5, Apr. 2020. [Online]. Available: https://telehealthandmedicinetoday.com/index.php/journal/article/view/187
[20] M. Alvandi, "Telemedicine and its role in revolutionizing healthcare delivery," *Amer. J. Accountable Care*, vol. 5, no. 1, 2020.
[21] M. A. Zambrano-Monserrate, M. A. Ruano, and L. Sanchez-Alcalde, "Indirect effects of Covid-19 on the environment," *Sci. Total Environ.*, vol. 728, 2020, Art. no. 138813.
[22] Pan American Health Organization, "Covid-19 information system for the region of the Americas," 2020. [Online]. Available: https://paho-covid19-response-who.hub.arcgis.com/
[23] D. R. Shakya *et al.*, "Covid-19 across countries: Situation and lessons for pandemic control," *J. BP Koirala Inst. Health Sci.*, vol. 3, no. 1, pp. 9–27, 2020.
[24] M. R. Ortiz and V. Sharma, "Modeling the Covid-19 outbreak in Ecuador: Is it the right time to lift social distancing containment measures?" *medRxiv*, 2020.
[25] "Coronavirus in Guayaquil," May 7, 2020. [Online]. Available: eluniverso.com/guayaquil/2020/05/07/nota/7834590/guayaquil-coronavirus-medidas-coe
[26] E. Lincango *et al.*, "Paradigms about the Covid-2 pandemic: Knowledge, attitudes and practices from medical students," *medRxiv*, May. 2020.
[27] I. Asanov, F. Flores, D. J. Mckenzie, M. Mensmann, and M. Schulte, "Remote-learning, time-use, and mental health of Ecuadorian high-school students during the Covid-19 quarantine," Washington, DC, USA, *World Bank, Policy Res. Working Paper*, no. 9252, 2020.
[28] Y. Siriwardhana, C. De Alwis, G. Gür, M. Ylianttila, and M. Liyanage, "The fight against the Covid-19 pandemic with 5G technologies," *IEEE Eng. Manage. Rev.*, vol. 48, no. 3, pp. 72–84, Sep. 2020.
[29] M. A. Benítez, C. Velasco, A. R. Sequeira, J. Henríquez, F. M. Menezes, and F. Paolucci, "Responses to Covid-19 in five Latin American countries," *Health Policy Technol.*, vol. 9, pp. 525–559, 2020.
[30] C. Fikar and P. Hirsch, "Home health care routing and scheduling: A review," *Comput. Oper. Res.*, vol. 77, pp. 86–95, 2017.
[31] M. P. Cruz, E. Santos, M. V. Cervantes, and M. L. Juárez, "Covid-19, a worldwide public health emergency," *Revista Clínica Española (English Ed.)*, vol. 221, pp. 55–61, 2021.
[32] I. Prieto-Egido, J. Simó-Reigadas, and A. Martínez-Fernández, "Interdisciplinary alliances to deploy telemedicine services in isolated communities: The Napo project case," *Sustainability*, vol. 10, no. 7, pp. 1–13, Jul. 2018. [Online]. Available: http://dx.doi.org/10.3390/su10072288
[33] A. Mian and S. Khan, "Medical education during pandemics: A UK perspective," *BMC Med.*, vol. 18, no. 1, 2020, Art. no. 100.
[34] F. Verhoeven, L. van Gemert-Pijnen, K. Dijkstra, N. Nijland, E. Seydel, and M. Steehouder, "The contribution of teleconsultation and videoconferencing to diabetes care: A systematic literature review," *J. Med. Internet Res.*, vol. 9, no. 5, pp. 1–26, 2007.
[35] J. Kern, "Evaluation of teleconsultation systems," *Int. J. Med. Inform.*, vol. 75, no. 3/4, pp. 330–334, 2006.
[36] H. Jeong, J. A. Rogers, and S. Xu, "Continuous on-body sensing for the Covid-19 pandemic: Gaps and opportunities," *Sci. Adv.*, vol. 6, no. 36, 2020, Art. no. eabd4794. [Online]. Available: https://advances.sciencemag.org/content/6/36/eabd4794
[37] G. Yang *et al.*, "Keep healthcare workers safe: Application of teleoperated robot in isolation ward for Covid-19 prevention and control," *Chin. J. Mech. Eng.*, vol. 33, no. 1, pp. 1–4, 2020.

[38] HRW, "Ecuador: Privacy at risk with Covid-19 surveillance," Jul. 1, 2020. [Online]. Available: https://www.hrw.org/news/2020/07/01/ecuador-privacy-risk-covid-19-surveillance
[39] X. Wang, Z. Zhang, J. Zhao, and Y. Shi, "Impact of telemedicine on healthcare service system considering patients'choice," *Dyn. Nature Soc.*, vol. 2019, 2019, Art. no. 7642176.
[40] UNDATA, "City population by sex, city and city type," 2020. [Online]. Available: http://data.un.org/Data.aspx?d=POP&f=tableCode:240
[41] T. P. Ryan, *Sample Size Determination and Power*. Hoboken, NJ, USA: Wiley, 2013.
[42] C. Wang *et al.*, "Immediate psychological responses and associated factors during the initial stage of the 2019 coronavirus disease (Covid-19) epidemic among the general population in China," *Int. J. Environ. Res. Public Health*, vol. 17, no. 5, pp. 1–25, 2020.

Bryan Pérez-Noboa received the B.Sc. (Hons.) degree in telematics engineering from the Escuela Superior Politécnica del Litoral, Guayaquil, Ecuador. He is currently a Technical Analyst in the public sector. He has been an instructor of courses related to calculus and advanced math at precollege institutions. His research interests include Internet of Things networks and technology management.

Aldair Soledispa-Carrasco received the bachelor's degree (Hons.) in telematics engineering from the Escuela Superior Politécnica del Litoral, Guayaquil, Ecuador. He is a Data Analyst in a telecommunications provider. His professional activities aim at data networks, app developments, and innovation, combining them with high-level programming languages, including Java, Python, and C++.

V. Sanchez Padilla (Member, IEEE) received the master's degree in telecommunications engineering from George Mason University, Fairfax, VA, USA. He is currently a Lecturer and a Researcher in the Telematics Engineering Program with the Escuela Superior Politécnica del Litoral, Guayaquil, Ecuador. His research interests include wireless network applications, engineering science education, and technology management.

Washington Velasquez (Member, IEEE) received the Ph.D. degree in telematics system engineering and the master's degree in telematics services and network engineering from Universidad Politécnica de Madrid, Madrid, Spain. He has authored/coauthored several papers in indexed journals and has led projects related to sensing and networking. He is currently a Professor with the Faculty of Electrical and Computer Engineering, Escuela Superior Politécnica del Litoral, Guayaquil, Ecuador. His research interests include telemetry, remote control, smart cities, and big data.