IoT health telemonitoring application for cardiovascular patients

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Abstract
The Internet of Things (IoT) is largely regarded as the most significant future technology, and the healthcare business is increasingly focused on it. The IoT is indeed at the heart of telemedicine, which makes it possible to facilitate the performance of remote medical procedures. We propose and develop the TeCa system (Telemonitoring of patients with cardiovascular diseases) an IoT-based web application which used the AD8232 ECG sensor and Arduino Uno to collect ECG data, which was subsequently kept in a database and shared with the doctor's caregiver. The proposed system allows a doctor to remotely interpret the data for the medical follow-up of a patient. The TeCa system keeps its usability since it does not require special knowledge to use it effectively.

Keywords
Telemonitoring, IoT, TeCa system, Cardiovascular patients, ECG sensors,

1. Introduction

The integration of Information and Communication Technologies (ICTs) in healthcare have become increasingly important in recent years to enhance patient care through telehealth [1]. The innovative sensor in wearables and other commercial health products offer great potential for real-world data collection. These technologies provide new methods of supporting and caring for patients at home, well-known Remote patient monitoring or medical telemonitoring [2]. Cardiology is among the most significant sectors of industry since integrated sensor technologies enable a wide range of applications, especially telemonitoring of patients' cardiovascular health status.

Telecardiology is diagnosing and treating of cardiac disorders such as congenital heart defects and heart failure by a distant clinician using videoconferencing and other technology [3]. It has improved the care of cardiac patients by increasing access to specialists not usually available in the region and reducing wait times for necessary care.

Telecardiology seems to have the potential to renovate the mode of cardiac care given in primary care settings [4]. Electrocardiography (ECG) is an important diagnostic tool that should be used in primary care for the detection and therapy of cardiovascular illness and cardiac

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arrhythmias. The Internet of things (IoT) has been used by the healthcare system to collect ECG data and provide home monitoring to patients with heart disease [5]. Also, the Internet of Medical Things (IoMT) is a grouping of medical equipment and applications that communicate with healthcare systems via online computer networks [6]. Given the millions of people who suffer from cardiovascular disease, a technology like telemonitoring will make a tremendous impact in properly controlling this long-term ailment and lowering the cost of treatment on a massive scale. To solve labour shortages and improve access to care, we developed a TeCa telemonitoring application for cardiovascular patients. The TeCa system automatically examines the patient's medical condition especially, ECG tracing via the AD8232 sensor. The data is then processed with an Arduino Uno and important information is recorded in a distributed database.

The paper is organized as follows: we give some important systems for telemonitoring cardiovascular diseases in Sec. 2 and describe the TeCa modelling in Sec. 3. Section 4 shows the setup of TeCa. Finally, we conclude the paper with Sec. 5.

2. Iot health telemonitoring applications

The COVID-19 pandemic has fueled telehealth adoption, using virtual care options for the first time in the last three years. Several applications for remote patient monitoring have been proposed. Cardiology remote patient monitoring is one of the most sensitive domains, which requires more attention than others [7].

Teladoc [8] is a unit of Teladoc Health, Inc., a mission-driven enterprise that is effectively changing the way people access and experience healthcare. This involves developing data-driven, tailored experiences that adapt to an individual's changing healthcare requirements. Clinicians may simply broaden their reach by using simple software and medical-grade telehealth equipment. Teladoc offers real-time clinical cooperation with peers worldwide to handle the most complex care concerns.

The digital front door of Orion Health is a secure, open, and scalable platform that enables businesses to integrate new and current patient interaction technologies into a single, user-friendly portal [9]. It addresses the fragmented consumer experience caused by silos by providing a consistent, easy-to-use, multi-channel interface through which all interactions, including symptom assessment, trusted health information, electronic referrals, access to complete medical records, virtual care, and remote monitoring, can take place.

MedM is an expert in Enabling Connected Health™ and a maker of award-winning remote care software platforms and personal health monitoring applications and portals [10]. It improves the quality of care and patient satisfaction while reducing the overall cost of healthcare. The principal aim of this system is to drive interoperability in the healthcare ecosystem, improving the speed of information exchange between all parties involved.

Our previous research is based on Wordnet and Wup's measure for automatic ontology learning from heterogeneous relational databases [11]. This approach has been validated in the food risks domain.

Recently, T.P.T.Armand et al. [12] develop a low-cost cardiovascular patient monitoring system (RPM) with wireless capabilities that could be used in any region of Cameroon. RPM is accessible, cheap, and capable of capturing important factors that accurately reflect the patient's condition and provide alerting mechanisms. In Cameroon, the availability of such remote monitoring applications remains a big innovation.

There have been several telecardiology encounters in the world of cardiology. The primary goal was most likely to create a relationship with primary care using teleconsultation methods, with varying degrees of success. Within cardiology, ECG can aid in the detection of arrhythmias, which occur when the heart beats too slowly, too rapidly, or irregularly.

In this context, we propose a telemonitoring application for patients with cardiovascular diseases. The application used two lead heart rate monitors via an AD8232 ECG sensor and Arduino Uno to transfer the data from AD8232 to the system. The developed TeCA (Telemonitoring of patients with cardiovascular diseases) system maintains user-friendliness and offers several tasks, such as selecting the preferred doctor, chatting with the doctor's caregiver, using the ECG sensor associated with an explanatory video on how to use the sensor, and delivering the electronic prescription, which must print it out by the patient or other patient's assistant. In addition, about the technical side, TeCa system is a web application programmed via the Django framework of Python programing language, which provides the possibility to extend the system by using artificial intelligence approaches, such as deep learning for auto-detection of anomalies, ChatBot if the doctor is not accessible, etc.

3. The Teca modeling

The aim of our work is to develop a system that helps patients to take care of their cardiac health at a distance, providing healthcare remotely, smart equipment, and remote medical operations. We used the Merise modelling method. In the TeCa system, there are three main actors:

- Patient: The person that will be consulted in our system. Its roles are: to check the doctor's list, the capability to reach the doctor's information, chat with its cardiologist caregiver, and measure the heart rate in real-time using an IoT device connected to the TeCa system.
- Doctor: The cardiologist, which will remotely consult the patient (consulting manager). Its roles are: to check the list of consulted patients and prescriptions given to them, Chat with the patient, and the capability to reach the patient's information.
- Admin: or website administrator ensures that a website is functioning properly. It is the one that validates the registration of doctors.

3.1. Treatments conceptual model

The treatments conceptual model (TCM) is one of Merise's most well-known diagrams. It enables the study of the information system's dynamics, i.e. the event-driven processes performed inside the system. The TCM figure of the patient is shown in Figure. 1.

We present TCM diagram of a doctor in cardiovascular disease, who uses our TeCa system (see Figure. 2).

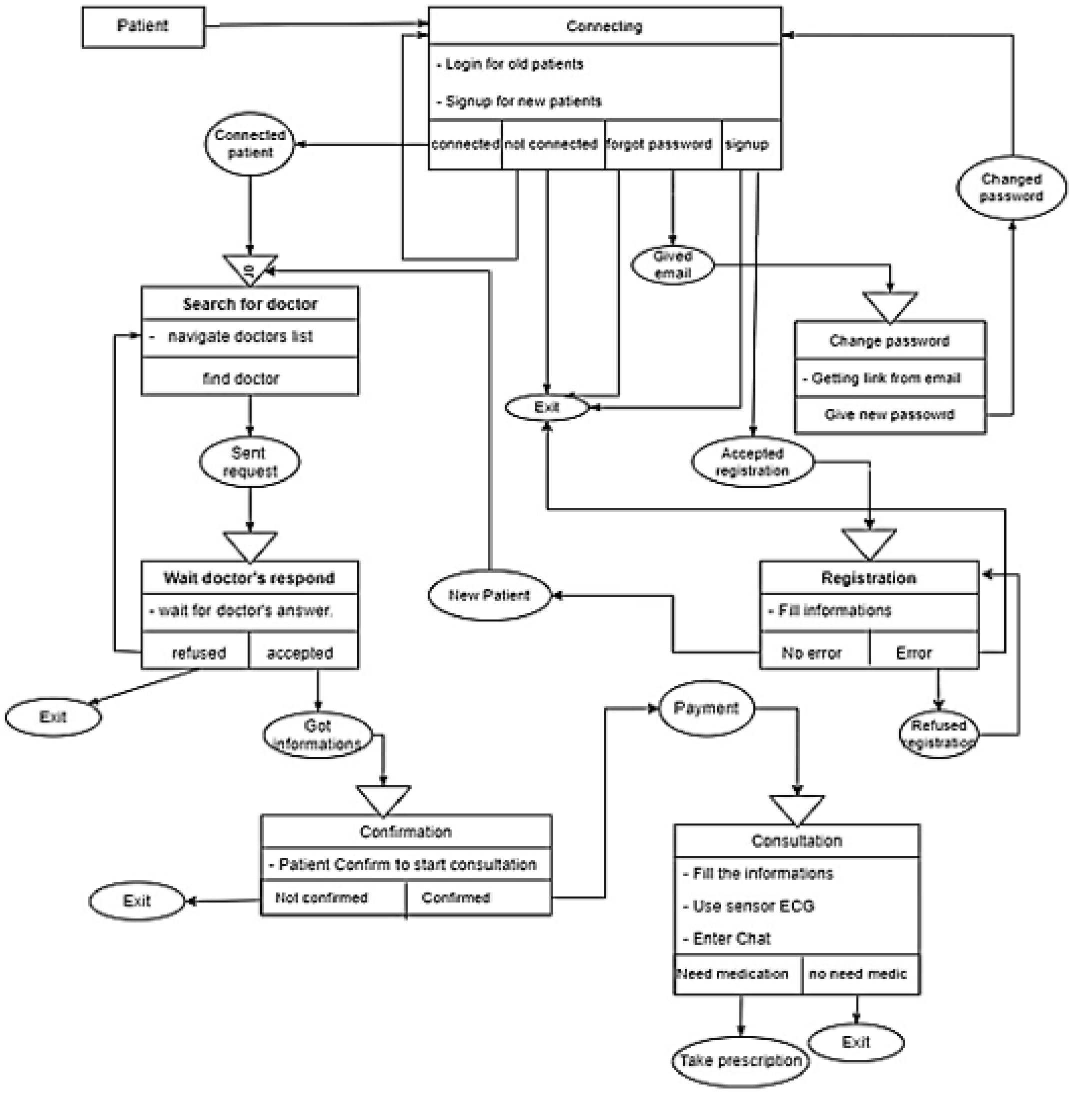

Figure 1: TCM of Patient

3.2. Conceptual data model

The conceptual data model (CDM) defines what the system contains. It aims to establish entities, their attributes, and relationships (see Figure. 3).

4. The Teca setup

The setting up of the TeCa system is performed on an AMD Quad-Core A8-7410 2.5GHz, RAM 8Gb. Python is used as a programming language with Django as a Python web framework

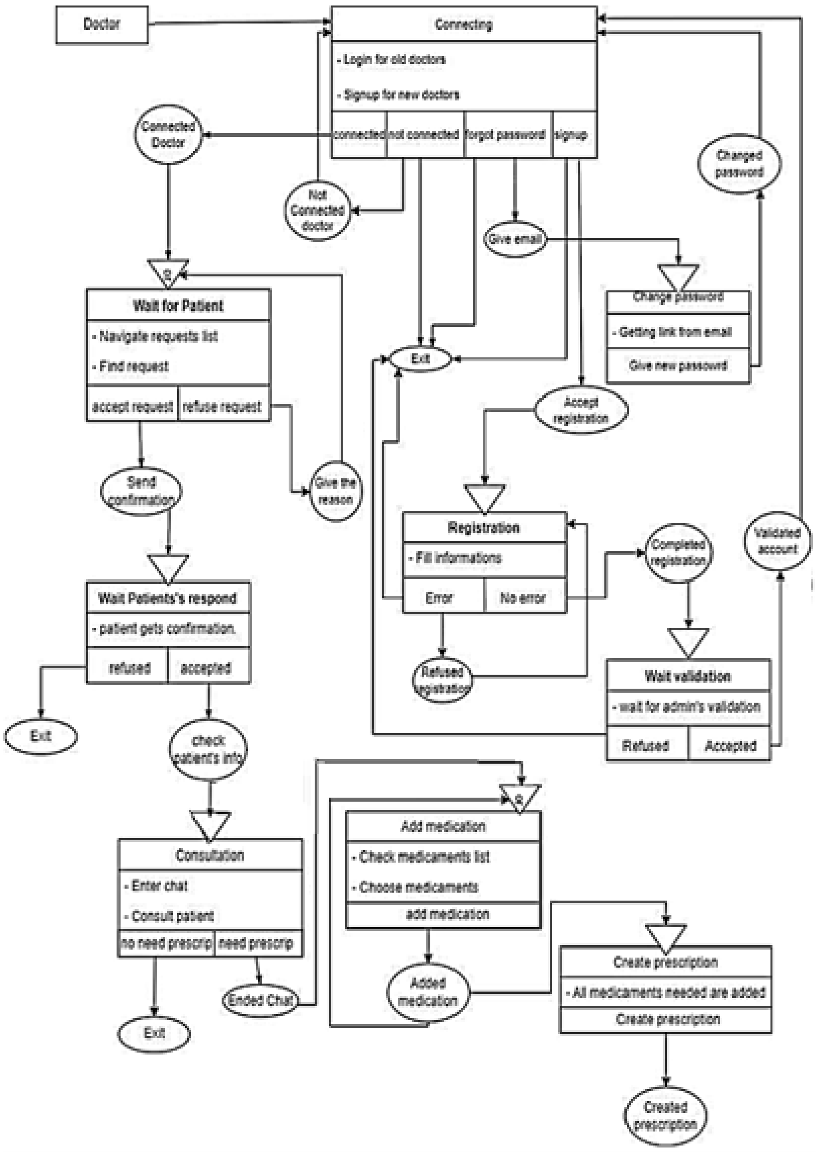

Figure 2: TCM of Doctor

with a high degree of abstraction that allows for the quick building of safe and stable websites. MySQL for storing data of patient, doctor, and ECG signal in the form of CSV, which will be used for displaying the ECG tracing.

The doctor can accept or refuse any received request (see Figure. 4).

After accepting the patient's request, the doctor will get information about the patient (see Figure. 5).

The patient can view the doctor's profile and send the request as a new patient or an old

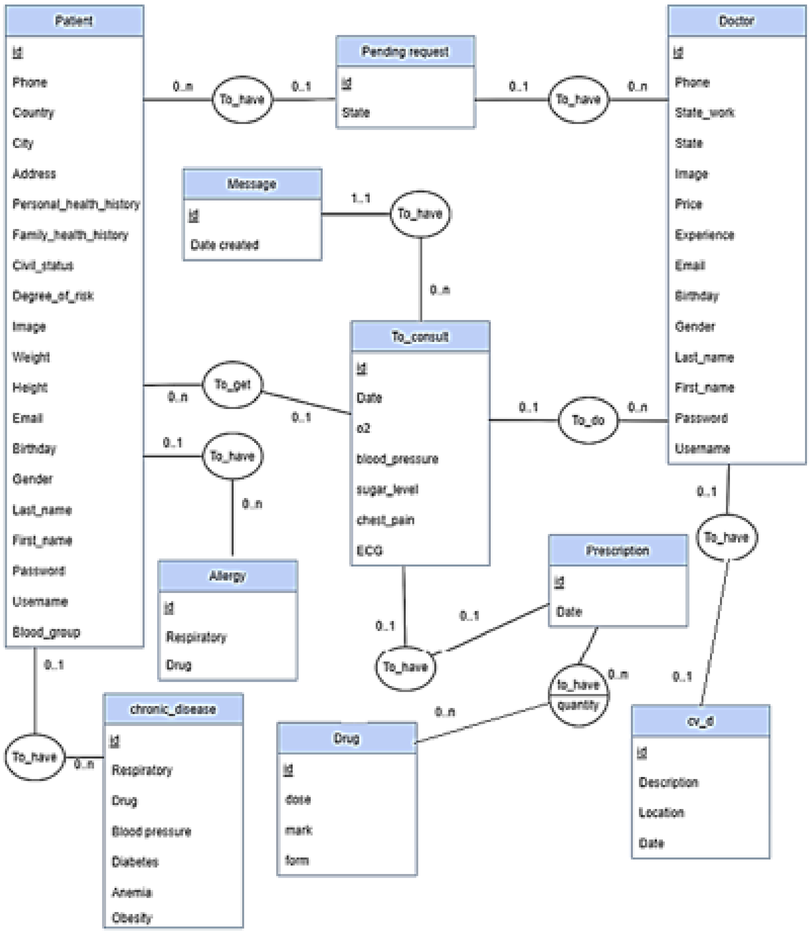

Figure 3: CDM of TeCa system

patient. The patient waits for a response from a doctor when the doctor accepts the patient has to confirm (see Figure. 6).

The patient must give his/her doctor the ECG result by following the five steps, which are presented in Figure.7.

At the end of the consultation and depending on the health status of the patient, the doctor can create a prescription. The patient can easily download his prescription in pdf format (see Figure. 8).

5. Conclusion

This article outlines the design and deployment of a cardiovascular health monitoring system. TeCa application services with home telemonitoring, patients would be able to live freely for a longer amount of time, lowering the expense of medical equipment and the need for extra

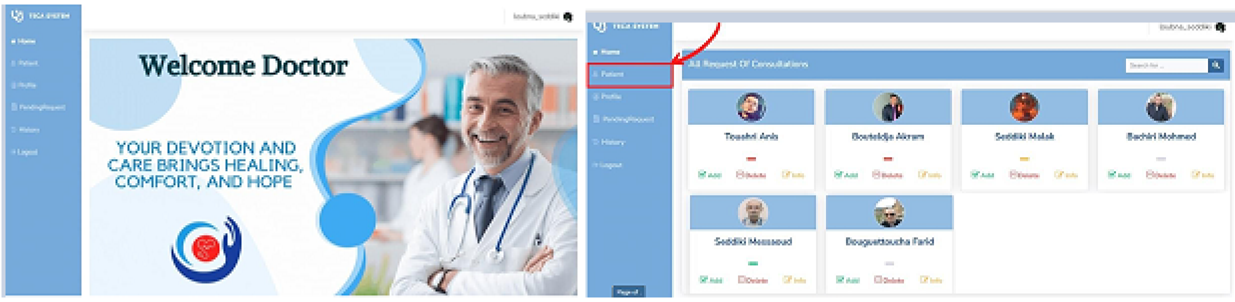

Figure 4: Patient request list

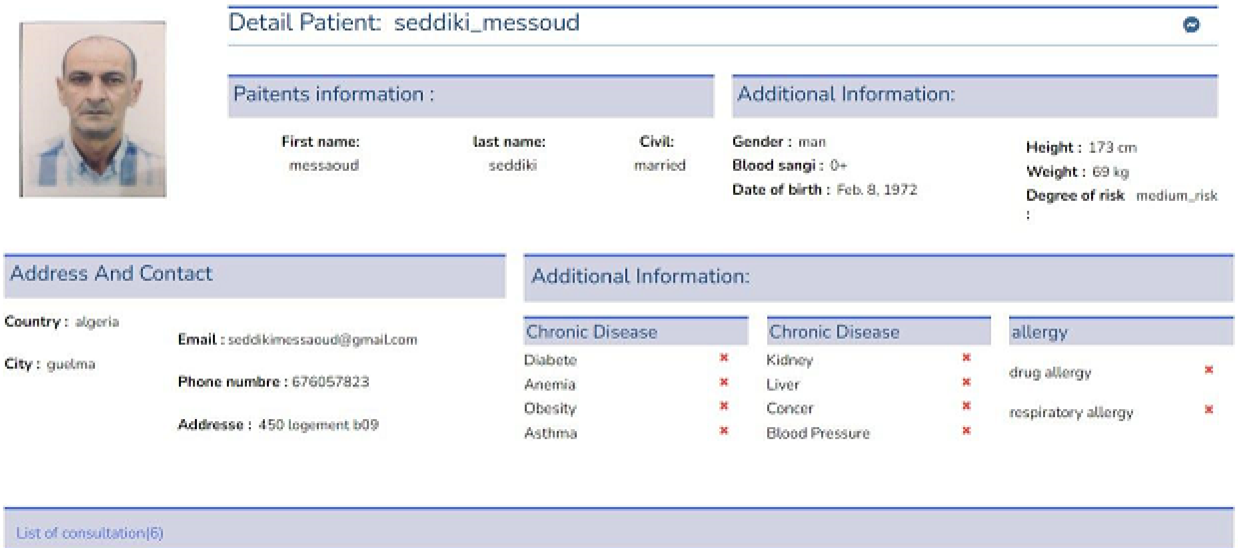

Figure 5: Patient information

caregiver services.

From perspectives, we are planning first to go ahead with our developed TeCa system in order to enhance its features: Intelligent application by using machine learning algorithms to replace the doctor with a robot and predicting heart disease, using a cloud server for storing the huge amount of medical data.

Finally, Federated Learning (FL), as an emerging distributed intelligence paradigm, is particularly attractive for smart healthcare, by coordinating multiple datasets to perform AI training without sharing data. We will improve the TeCa system in different healthcare centres and develop a platform for distributed intelligence, keeping data secure and private.

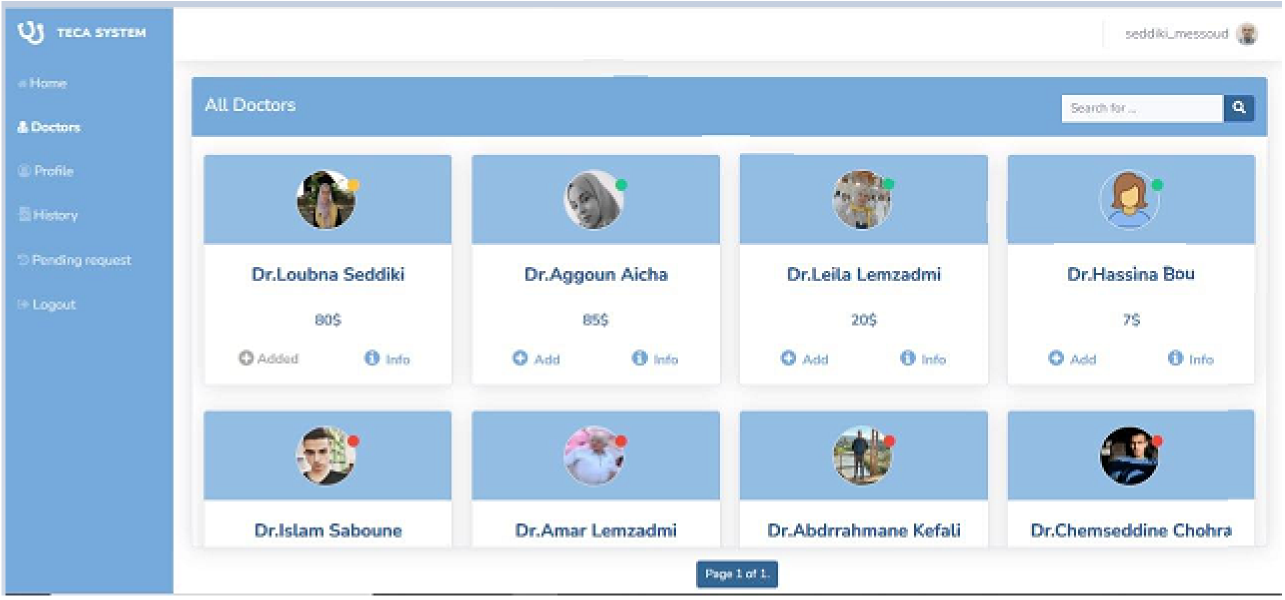

Figure 6: Doctors list

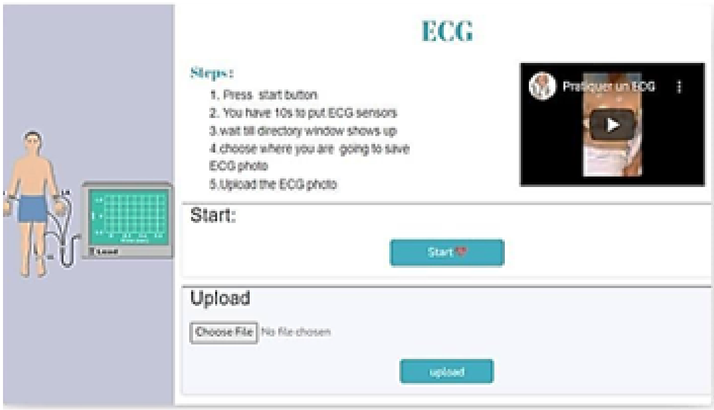

Figure 7: ECG setting

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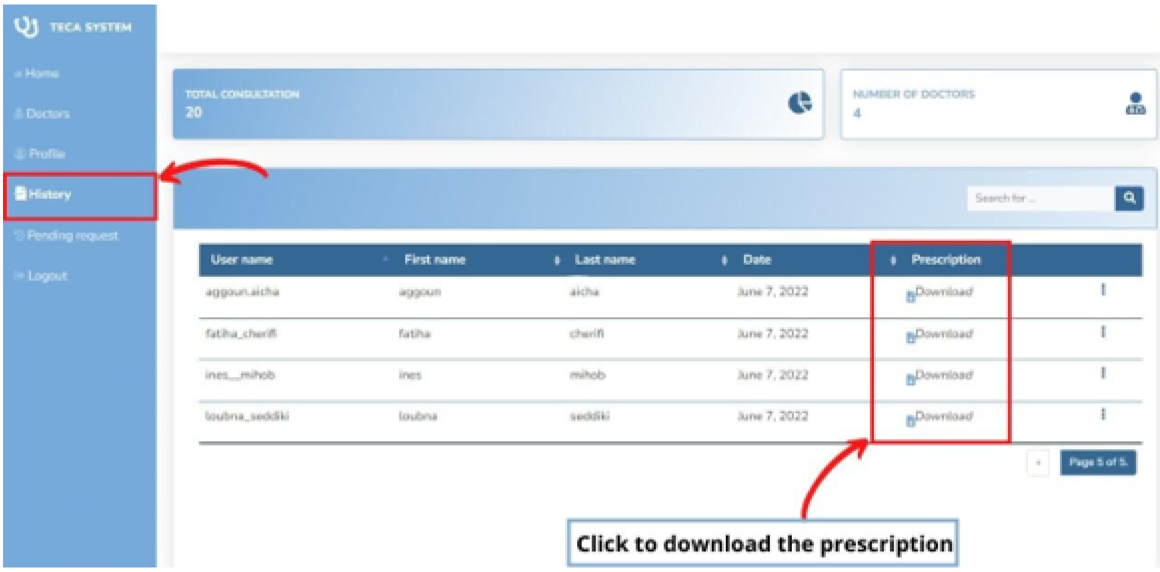

Figure 8: History Page

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