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An Integrated Management System for a Medical Center

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ABSTRACT

Recently, the use of technology in medicine and healthcare has increased, particularly during the pandemic period. This adaptation has shown to be fruitful in many scenarios. Implementing a computerized system to manage daily tasks like handling patient records, appointments and other administrative tasks can result in an efficient system. This will in turn result in a better experience for the patients as well as the staff members. This research paper documents the development process of creating an online web application for an existing manual medical center management system. The previous system made simple and frequent tasks like retrieving laboratory results or checking a doctor's appointment a time-consuming hassle. Further, the requirement of a digitized system to track the medical staff was evident as many incorrect appointments and patient records were detected. This proposed system provides the benefits of appointment management, laboratory management, staff management, payment management. This solution makes it easier to check staff profiles and schedule appointments for patients, preventing making an appointment for a doctor on a day. Additionally, the laboratory division may post reports and this system manages all the patient payment details. The proposed system's functionalities will next be discussed, along with the testing methodologies and outcomes.

Keywords-- Healthcare, Appointments, Online Web Application, Proposed System

I. INTRODUCTION

Good eating habits, frequent exercise, and yearly physicals are all necessary for leading a healthy life. However, the hectic and unhealthy lifestyles of today's generation are causing them to experience a variety of health problems even at a young age. Particularly, the number of persons with non-communicable diseases, including cholesterol, heart failure, and diabetes is dramatically rising. Non-communicable diseases are responsible for about 71% of all fatalities globally. This could be even more harmful because some diseases don't initially exhibit any symptoms, making it difficult to diagnose and treat the illness in a timely manner. Because of this, early detection of many illnesses is essential for a quicker recovery and a healthy, long life. But today's generation does not like to get medicines and meet a doctor for a small reason. One of the main reasons for this is the lack of time and if medical centers use management systems to manage their works it can save people's time. The current generation is highly reliant on the Internet as they live in a highly technological era. For most problems, there are numerous solutions that can be found on the Internet. However, there are still some sectors in Sri Lanka, that people hardly use the Internet to find solutions. when we investigated found that even though there are many E-channeling applications available, but there are very few numbers of web solutions available in Sri Lanka related to medical centers. Lots of medical centers are using hard copies to take their reports.

So obviously a typical e-channeling application won't be enough if medical centers are not using management systems to do their work. As a solution to this problem, a system must be implemented in a way that medical centers will not be confused when they are managing their works that are unfamiliar to them in the application. We are going to introduce a new web application management system solution for medical centers to use as a platform to manage their work.

This research paper has been divided into distinct sections to provide a more complete discussion of the solution. Current E-channeling and medical center management web application solutions are discussed in the related work section below. Technologies and how they were used to develop the solution are discussed in the methodology section. The proposed system section discusses our solution's main functionalities and how they work. The discussion section explains how created core functionalities to solve issues with existing web applications. Finally, a conclusion is provided considering the experience, gathered information and insights from the

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development process and a list of the resources used is included in the references section.

II. LITERATURE REVIEW

There have been a variety of medical center management applications proposed in literature [1], [2], [3] and [4]. Further, many publications highlighting the positive impacts of computerized management systems for medical institutions can be found like [5] and [6].

The project in [4] proposes a database management system which allows doctor, patients, and administrators to maintain data related to a hospital effectively. Functionalities like booking appointments, obtaining online prescriptions and general management of patient and doctor data are proposed. Further, the development cycle, architecture and final outcome after implementation are discussed in detail.

The proposed system in [7] focuses on preventing inaccurate reports and redundant data. This is achieved by a patient management system for a hospital by following a flexible RDBMS (Relational Database Management System) structure. This system is divided into three main modules namely, receptionist's, doctor's, and pharmacist's module. The receptionist's module mainly focuses on creating patient accounts, verification, searching data and customer communication. Similarly, the doctor's module handles appointments, laboratory, and patient discharges. The pharmacy module handles the patient prescriptions, payment and receipts.

The paper [8] discusses a system designed for streamlined operation of administrative tasks. The frequent errors occur in such a busy system are discussed and a thorough analysis of existing manual systems in hospitals are provided. The main goal of the system is providing an efficient system for patient appointment management. Further, the project management, risk management and testing involved are highlighted.

Even if a perfect software system for patient and doctor management is implemented the process of verifying a person can take additional time. The system proposed in [9] uses a Radio Frequency Identification (RFID) system to quicky identify an individual along with a comprehensive patient-doctor management system. The insights gathered from this project can help evaluate the advantageous of implementing such a function in the system discussed in this paper.

The publications discussed above provide insights into information gathering, project management, risk management, implementation, and testing and thus the obtained knowledge and statistics are taken into account for the current work.

III. METHODOLOGY

The technology stack utilized for this system is MERN Stack and it includes MongoDB, which is a NoSQL component for the database, Express.js which is a backend web application framework used for NodeJS, ReactJS which is a JavaScript library for developing user interfaces and NodeJS which is the runtime environment. (Table 1)

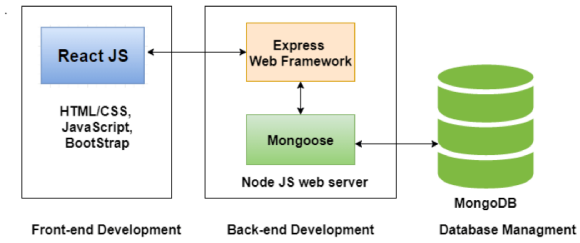

Figure 1: MERN Stack Development

Some alternatives for the MEARN stack are the MEAN stack which replaces react with angular, the MEVN stack which replaces react with Vue.js and the LAMP stack which utilizes Linux, Apache, MySQL, and PHP. To compare these technologies their performance, architecture, availability of third-party libraries and current trends in the industry were some deciding factors considered. React has proven to have better performance, more third-party libraries and overall, more support. Therefore, it was chosen over frameworks like angular.js and vue.js. Further, the MERN stack is more popular and trusted within the industry. According to the International Journal for Recent Research Aspects, React.js is chosen in the industry for its security, low latency, and increased performance with powerful servers [10].

Usage	Technology/tool
Front-end	ReactJS
Back -end	NodeJS with Express framework
DBMS	Mongo DB cloud database

Table 1: Used Technology/Tool

A methodology which allowed rapid development of the application was required as it was being developed within a short time frame. Accordingly, a methodology which was simple and logical seemed appropriate. The Waterfall methodology seemed to be a perfect fit for the requirements thanks to its logical structure consisting of sequential phases (Figure 2). The project would proceed from the initial requirement analysis stage through design, implementation, testing and finally maintenance.

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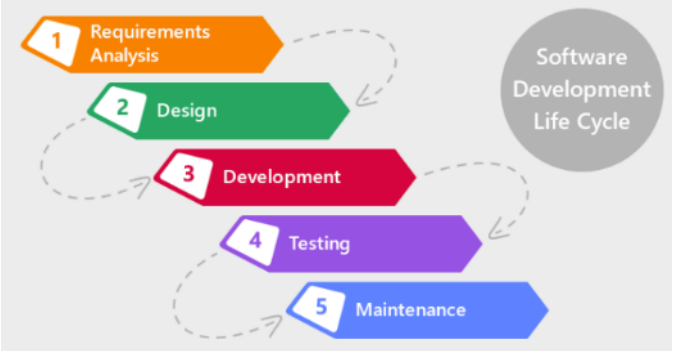

Figure 2: Waterfall Methodology

A. Requirement Analysis

An application for managing different aspects of a healthcare center requires reliable and accurate functionalities. A failure in this would result in countless hours of the patient's time being wasted or even critical functions in the healthcare center being delayed. Therefore, this was one of the major requirements considered during this phase. In order to achieve this, various medical professionals were included in the requirement gathering phase. Different techniques like interviews, questioners and brainstorming sessions were conducted. The gathered requirements were then analyzed to obtain a thorough understanding of the expectations of the end users. The requirements for appointment management and laboratory management were mainly focused here. Further, the system being developed was intended for administrative staff as well. It required functionalities for medical staff management as well as payment management for various appointments, laboratory tests, etc. For the above functionalities the existing manual system used by the institute was analyzed and the function scopes were defined.

B. Design

The design process was a critical phase in this project as there is limited opportunity to revisit this step in the traditional waterfall model [11]. Further, the project being developed within a short time period made revisiting almost impossible. In order to deliver a successful application on time every minute detail in the requirement specification was considered and the system was designed accordingly. The backend architecture was designed so that it allowed better separation of code and feature encapsulation. Since the system contains many interrelated functionalities creating an effective database design was as equally important.

Next, the usability design was considered which should underline the user-centric policy followed when developing the project and should be reflected throughout [12]. Here, the user interfaces were designed so that it allowed maximum user friendliness while providing an efficient virtual workspace for the medical staff to ease their daily processes. Finally, the design document was created and the

C. Implementation

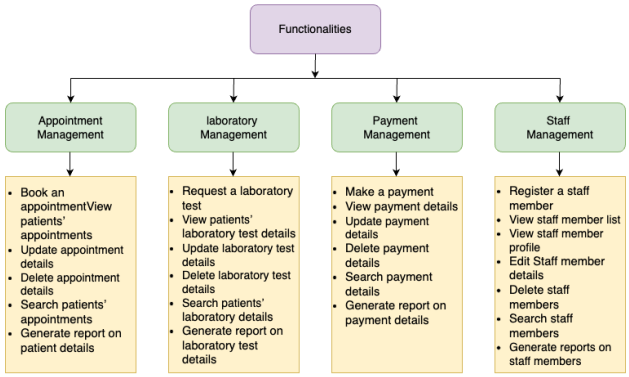

Figure 3: Functionalities

With the requirements (Figure 3) clear and a comprehensive design document made the next step was to actually implement the application. The implementation process started with the back-end server and database and eventually extended to front-end user interfaces and features. Extra care had to be taken during this process as errors that are found after the implementation phase have proven to be expensive and time-consuming to fix.

A quality gate checklist and unit testing were used to ensure that errors were minimized, and a functioning system was delivered for testing

D. Testing

It is time to check whether each module works. This step is where all the units developed with inside the implementation segment are incorporated proper right into a system after attempting out each unit. The testing team receives the code and testers run test cases either manually or through automation. This phase may also include users training to communicate instructions or benefits of the system in order to ensure all requirements are met.

Specially earlier than a medical care system may be launched to customers, finding out wants to be completed to ensure the system has no mistakes, and all the necessities were finished, ensure an excellent user revel in with the software. If a health care system has a failure it may result in giving false reports to the patients.

E. Maintenance

After installation, this step includes editing the system or a particular component to alternate characteristics or enhance performance. The system is furnished or deployed to the user for usage following successful testing. The maintenance phase begins after deployment. It's also a phase to identify any errors you might have missed during the testing phase.

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These changes result from either customer-initiated change requests or flaws found when the system is being used in real life. Especially when it comes to a system for health care, the requirements may change from time to time. The developed software is regularly maintained and supported for the client.

Advantages Of Waterfall Model On Proposed System:

- Easy to understand and placed to use.
- Works well for smaller projects where the requirements are clearly established
- The model's tension makes it simple to control.
- Each phase is processed and completed separately.

IV. PROPOSED SYSTEM

A web application is proposed for medical centers to use as a platform to record their appointments, lab tests, staff details and payment details. The entire web application is separated into four main functionalities before implementation of the solution began. They are namely appointment management, laboratory management, payment management, and staff management.

A. Appointment Management

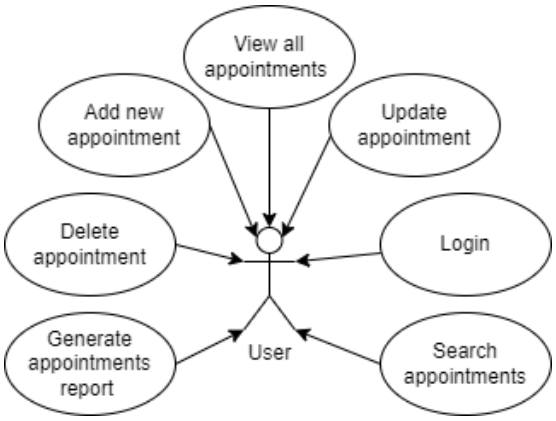

Figure 4: Appointment management

This is the Main functionality of the system which covers the Appointment Management function (Figure 4). To start using the system, first client's login to the system and the login functionality has been provided with authentication to prevent bots from impersonating the user. Additionally, encryption has been employed on the back end to safely store the password.

After login to the system, the user has a privilege to make an appointment, view all appointments and user can update appointments and save them so that they can view updated appointments if a user wants to remove any appointment, he has privilege to delete any appointments.

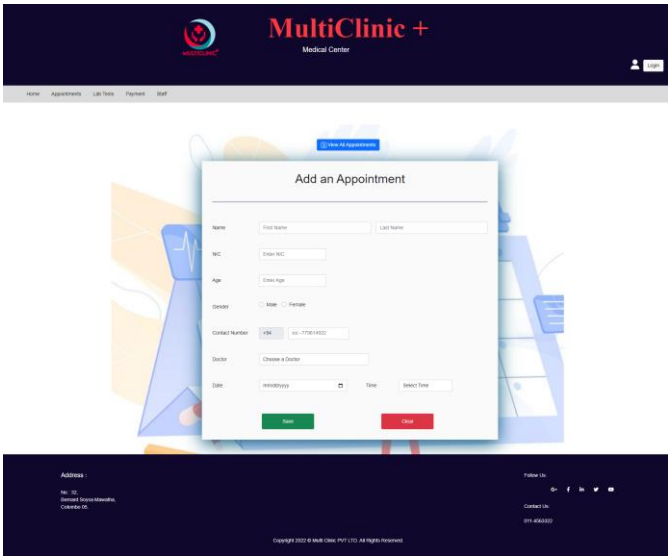

Figure 5: Add an appointment

In this proposed system appointment management, part user is the receptionist, and this user can create an appointment by clicking "Add an appointment" button, which appears on the appointment dashboard. It will navigate to another user interface where the user can add an appointment to the system (Figure 5). He can make a new appointment by filling in a form. This form asks about patient details, which doctor they want and the date and time of the appointment. Then the system checks the validity of the given details. Then these new appointment details are stored in the database.

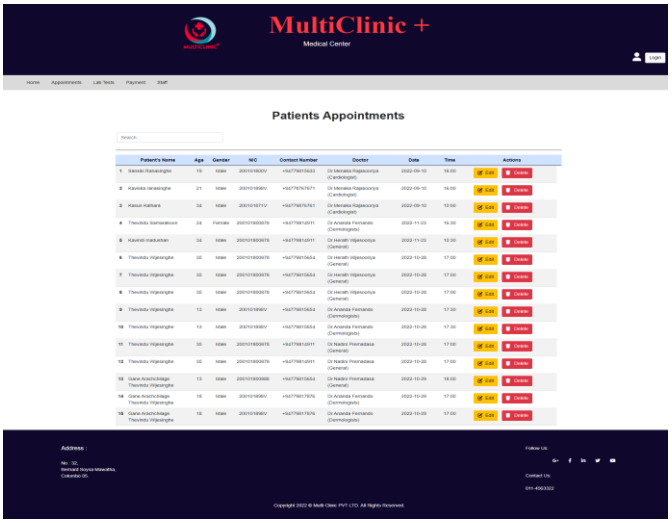

Figure 6: View, Update, Delete Appointment

This proposed system user can view details of all the appointments by clicking "view appointment" button. This button appears in the appointment dashboard (Figure

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6). This button navigate to another user interface in this interface user can view all the appointments. If the user wants to update or delete any appointment user can click on update button, then it navigates to an interface that shows detail of relevant appointment and user can update that appointment and save it. And if the user wants to remove any appointment user can click on delete button it shows a popup message to confirm it. Furthermore, the admin can also create reports on the appointment in the system. The purpose of this report is to show how many appointments are added to the system in a specific period. These reports can be viewed, downloaded, and printed as required.

B. Laboratory Management

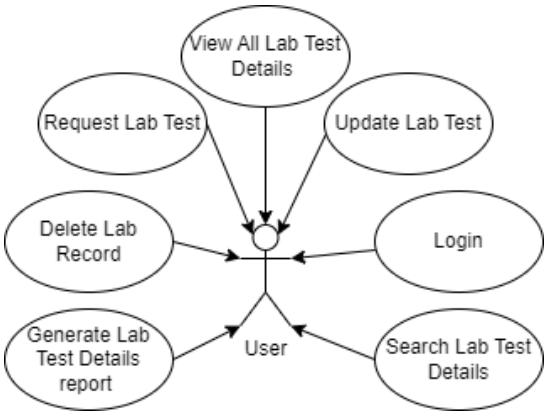

Figure 7: Laboratory Management

In the medical field, laboratory tests are important things. When it comes to illness diagnosis and prognosis, similarly to in hazard stratification, treatment preference and evaluation of the reaction to it, and observation of the reason of disease, laboratory tests playing an important auxiliary role. [13]

According to the proposed software product on medical center management, laboratory management was one of the main functions. The current system in the laboratory management use a manual paper-based system. It cannot provide an updated list of test details within a reasonable timeframe. In the proposed system, the laboratory management function handles the patients' lab report details. In particular, the receptionist, who is the main user of this system, handles this function (Figure 7).

Patients' requested laboratory details will be added to the system by giving patients details such as person's name, ID, contact number, age, and laboratory test details such as lab test name, laboratory technician, laboratory room number, test date, and laboratory test fee (Figure 8). Furthermore, the test status can be updated from pending to completed (Figure 9). According to the laboratory fee added in this function, payments can be handled by the payment management component in the system by using it.

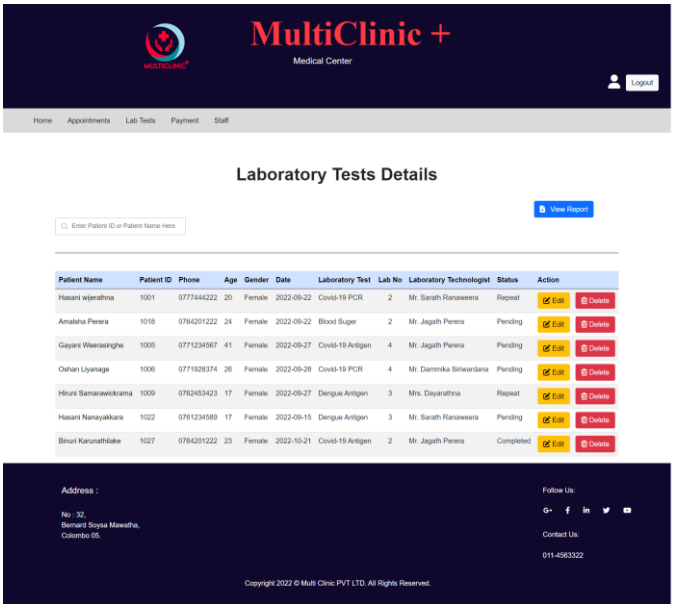

Figure 8: View, Update, Delete Laboratory Derails

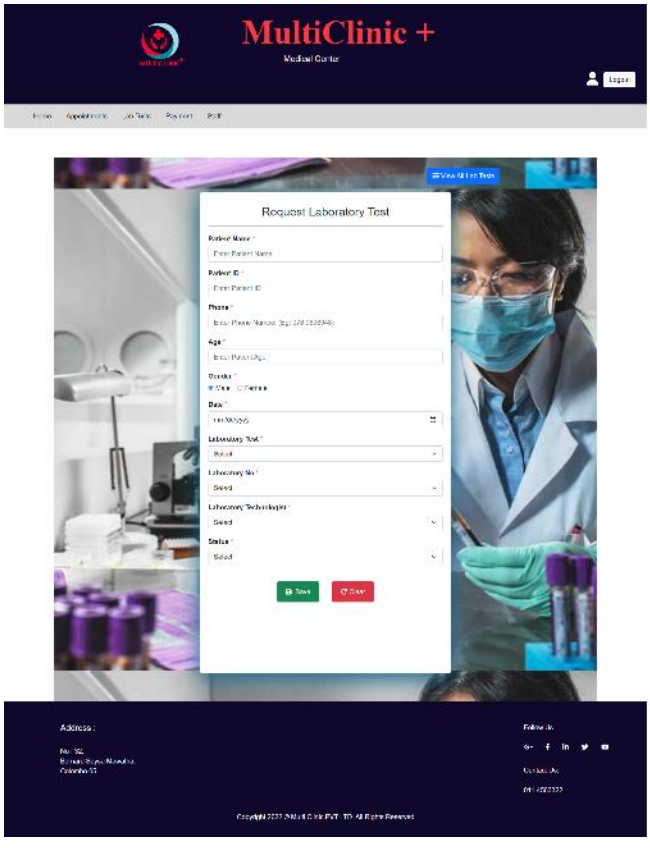

Figure 9: Request Laboratory Test

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According to the main requirements of the stakeholders, the front-end user interfaces were designed and implemented in a friendly manner to be used by the user (Figure 8, Figure 9). To keep records of patients' laboratory requests, the request lab test details form was implemented. Then the end user is able to view the existing laboratory request records and is able to update the status of each report and delete the records. Also, it provides an interface where the user is able to view a summary of the test record and generate a report.

Laboratory functionalities, which are mentioned in the proposed system, are handled by the laboratory control class in the backend. Then the laboratory model class provides a clean interface to interact with the Mongo DB database through the Mongoose library and manage laboratory details.

The intention of the function of this system is to scale back overtime pay and increase the quantity of patients which will be treated accurately.

C. Payment Management

The payment management function is not entirely digitalized. The majority of the processes, such as adding customer payments, view payment histories require a lot of paper and take a long time. The focus of this function has been on minimizing the paperwork and time required for these processes. Also in this function, we have implemented a report generation part that can predict the total count of payments. This process is specifically handled by the receptionist, who is the system's main user.

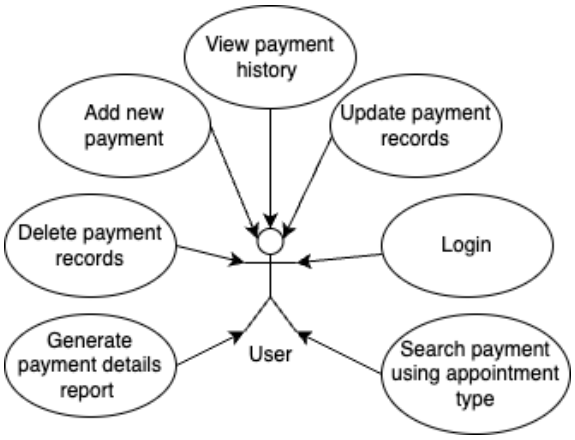

Figure 10: Payment Management

The payment management function manages the financial aspects of a patient's lab tests or doctor's appointment in the proposed system. By providing patients with information such as a person's name, contact information, date, payment amount, and appointment information, payment details will be added to the system. There are two categories of appointment types, including those for medical appointments and appointments for lab tests.(figure 11)

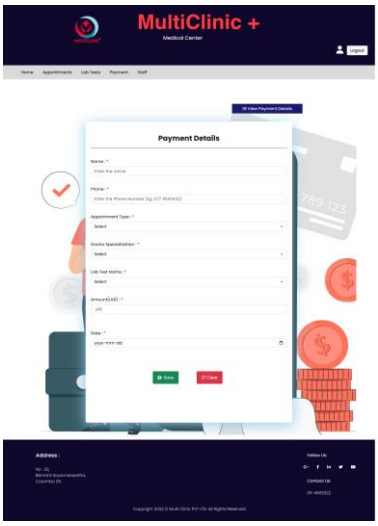

Figure 11: Add Payment Details

The front-end user interfaces were created and implemented in accordance with the main requirements of the stakeholders in order to be user-friendly. The added payment details form was implemented to keep track of patients' payment information. The end user can then view all payment records, edit payment details, and delete payment details records (figure 12). Additionally, it offers a user interface that enables them to view a summary of the payment history, to get a count of payments, and generate a report (figure 10).

This system's purpose is to handle processes by providing an automated, systematic, and accurate payment management cycle that is effective, efficient, and updated in real-time.

D. Staff Management

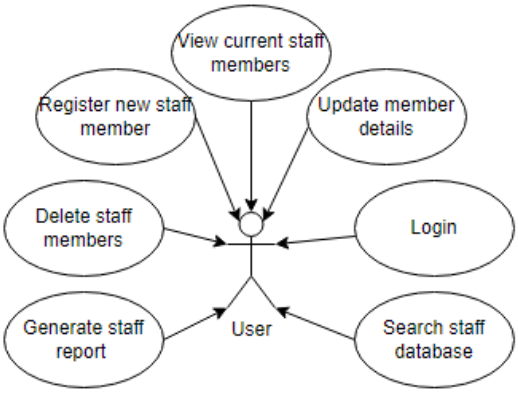

Figure 12: Staff management

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Providing the healthcare center, the ability to efficiently manage their staff members was another main requirement provided by the stakeholders. The proposed system included this functionality so that medical staff in the institution can be registered to the system and their details maintained for easy access (Figure 13).

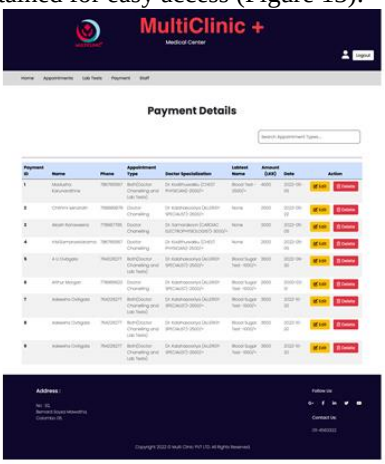

Figure 13: View, update, delete payment

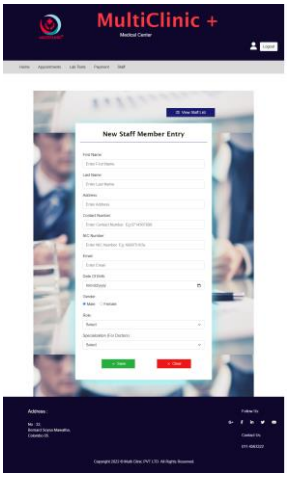

Figure 14: Register Staff member

Updating the user details and if necessary, removing a staff member were functions implemented. The managed medical staff included doctors, nurses, and lab assistants/technicians (Figure 14). The end user can view the staff details from the staff profile page and the record can be updated or deleted form that interface shown in figure 15.

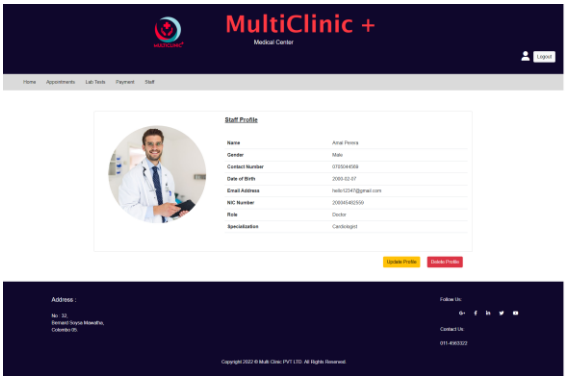

Figure 15: Staff member profile

Information like the specialization of the member and shift details were included so that it could be used by other components of the system like creating appointments and managing lab tests.

A staff member model class was used in the backend for managing the member details between the database and server as well as within the server. Next, a staff member control class was used to implement the functionalities like creating, updating, and searching staff members. A route file was used to expose the functions implemented in the controller class so that they could be utilized using the REST (Representational State Transfer) API (Application programming interface). Next, the routes were exposed by the server.

The front-end UI (User interfaces) were implemented so that the end user could manage the staff member details comfortably. Some of the main interfaces implemented were for adding a new staff member, updating existing staff member, viewing the existing staff members' details, and generating reports related to the medical staff.

Further, the proposed system provided extensibility with ease. Functions like managing attendance, work hours and employee salary management can be added to the system hassle free incase the stakeholders decide to.

V. DISCUSSION

Upon investigation of the medical center in Sri Lanka, it was evident that most were still not taking advantage of web-based solutions. Because of this most medical centers manually write their records as hardcopies. This method was proven to have several drawbacks evident from the user research and requirement gathering phases. Accordingly, the findings and results obtained in the project implementation and maintenance phases are discussed below.

For testing the major functions in the systems unit testing was carried out first, for the individual functions and later the entire system was tested together. For testing the

frontend UI, a combination of automated testing with Selenium and user acceptance testing was conducted.

A. Appointment Management

This feature inside the medical center management system helps the user to easily add a new appointment as per patient needs. Not only that user can view all the appointments details and update any as required, and user can delete any appointment and generate appointment reports.

Statistics	Mon.	Tue.	Wed.	Thur.	Fri.
Total Number of patients present	594	543	424	344	306
Total Number of patients Seen	497	454	349	300	270
Total Number of patients Not Seen	97	89	75	44	36
Total Number of Old patients	263	259	202	192	183
Total Number of New patients	331	284	222	252	123
Total Number of Male patients	219	192	180	118	114
Total Number of Female patients	375	351	244	226	192

Table 2: One Month Statistics of Patients' Visiting Medical center

According to statistical analysis of data taken from a hospital's patient record book, (Table 2) there were a total of 2211 patients present for a one-month period, of whom 1,870 (84.58%) were seen, 341 (15.42%) were not, 999 (45.18%) were old (reviewed), 1,212 (54.82%) were new, and 823 (37.22%) were male and 1,388 (62.78%) were female. These patients need quick medical care due to a variety of health issues. Because of that, this appointment management can save people time and give them a specific date and time to channel a doctor.

B. Laboratory Management

The issues with the manual system that was in place were resolved by the system. Obtaining a patient's lab test records used to be time-consuming and complicated due to paperwork. This is prevented by the management function of the laboratory. As a result, the records may be easily found by the end user through the view list and search functions. Additionally, errors like the modifications to the test status that may happen in manual systems are prevented.

According to guidelines based on evidence to eliminate repetitive Laboratory Testing, even though laboratory expenditure regularly shows much lower than 5% of most health center budgets, the effect is achieving for the reason that laboratory tests have an impact on almost 60% to 70% of all clinical decisions. [14] So, that having laboratory test facilities is profitable to hospital and it's a need. And if it is automated it would be an ease. The suggested system was implemented in a setting where its functions were previously performed manually, thus after the laboratory test becomes accustomed to the system, a more notable growth can be anticipated.

C. Payment Management

The system's end users were able to avoid the complications that came with the manual system after the payment management component was added. The new system was capable of preventing errors like entering the wrong appointment name, the incorrect amount, or losing information about payment history. In addition, the system's effectiveness appeared to be increasing exponentially. Adding a new payment to the database, updating payment records, and generating payment history reports are just a few of the tasks that used to take several minutes to complete.

[15]This was one of the few studies to look into how hospital ownership (public, private, etc.) might affect unofficial payments in hospitals in low- and middle-income nations. According to our research, 11% of doctors and 30% of hospitalized patients in all types of hospitals received unofficial payments from other staff members. Compared to those admitted to social security and private hospitals, patients admitted to teaching hospitals were significantly less likely to make unofficial payments to doctors. The results of the current study were comparable to those of studies from Greece and pre-reform Turkey, where the rates of informal payments were, respectively, 36% and 31%.

D. Staff Management

After the staff management part was included in the system the end users were able to avoid complications faced during the manual system. Mistakes like assigning staff members tasks outside of their shift, interchanging staff members, misplacing staff contact information are some such complications that the new system was able to avoid. Further, an exponential improvement in the efficiency of the system could be seen. Tasks that took several minutes to complete were now being completed within a few seconds such as registering a new member to the medical staff, updating contact information, and generating human resource reports.

The addition of a system to manage the staff attendance and salary to the system proves to be advantageous. The hospital being able to automatically update doctors available for appointments, the laboratory staff available and the number of nurses available for a ward are some examples. The Journal of Operations management states that 60 to 70% of the budget for a typical hospital is used for nursing costs. Often implementing a system to manage the nursing staff and related processes may result in a restructuring of the organization and business process. According to the above journal over 9% growth was seen in the health care industry in the 2003 thanks to implementation of new technologies [16]. As the proposed system was implemented in an environment where its functions were conducted manually

earlier more significant growth can be expected after the staff is familiarized with the system.

VI. CONCLUSION

Managing a healthcare facility can get difficult as patient numbers rise, but it can be made simple with an effective and efficient system. The key aspects of a patient's healthcare are an effective information management system, making it suitable for handling emergency situations. The papers that have been reviewed here focus on research on medical center management systems, but they pay little or no attention to how modern technologies are being incorporated into medical center management systems to handle patient emergencies. In order to improve patient care, patient safety, efficiency (by allowing access to patient historical medical records, reducing the stress related with tracking records, reducing waiting times, and increasing the number of patients served), and fee, this work aims to analyze, design, and implement a system. It offers simple access to critical information, enabling management to quickly decide better course of action while caring for patients.

The medical field will greatly benefit from this work.

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