

Extending Incident Reporting System For Patient Health Care And Safety In A Rural Areas –A Case Study Of Abwa, Saudi Arabia

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Abstract: This system is based on integration of web technology and wearable sensor technology that provide a web interface between the doctor and the patient for communication. This system is very helpful in diagnosing and treating the patient online and can solve the issue to a great extent for the people living in rural areas. The doctor receives an alert message once any incident is uploaded. In addition this system will help the user for searching the specialist doctor, making an appointment and follow up electronically. The patient history can be retrieved easily. A case study about incident reporting in rural areas is incorporated. User can manage and take care of sufferers related to common problems as well as age-related diseases such as diabetes, heart disease etc. in the rural areas. This will save the time of the patient and the hospital staff. To understand the real user experience Usability Test Analysis has been carried and found convenient, reliable and secure for the rural areas people. ASP.Net, C-Sharp programming language, SQL Server, JQuery, CSS, Ajax and wearable sensors are used to develop this customize system for taking care of health issues of the patient.

Keywords: Wearable sensor, online diagnosis, Remote areas, ASP.Net, C#, SQL Server, JQuery, CSS and Ajax.

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I. Introduction

In rural areas implication of health care issues are increasing with high rate because of lack of proper diagnosis and treatment of the patient. This enhances the requirement of health care monitoring system for rural area for elder or aged patients [1]. Inform of tiny patches [2] wireless sensor can be used. Marcy et al. [3] showed an example of an implantable sensor. Many studies [4-6] indicated that monitoring human physiological information by means of a sensor in real-life conditions is especially useful in the management of chronic disorders or healthcare problems. By integrating wearable sensors either with Web or Mobile communication health care services can be managed at home. So this integration facility shifted the health services from clinic-centric to patient-centric referred to "Telemedicine" [7]. This will ease long term monitoring for the treatment related to chronic disease as well as common problem of the people living in rural areas [8]. Efficient and reliable electronic hospital management system has been an issue over the years for managing health care in remote areas [9]. Automation systems in hospitals [10] serve the purpose of providing an efficient working environment for healthcare professionals. There is a need for reliable application [11] that addresses health care practices for the rural areas people such as patient status management, an appointment with a doctor, fast and reliable retrieval of patient history etc. in order to provide ease to them. Hospital Management System (HMS) is custom built to meet the specific requirements of the medium and large size hospitals across the globe. In most of the case according to the user requirement HMS needs customization. Through Electronic Commerce (EC), the organization can increase their economic growth, reduce transaction cost and improve efficiency and effectiveness [12]. This system also provides online appointment facility to the registered user for the consultation with a specialist doctor and follow up reminder on the due date by means of a message.

A case study about incident reporting is also incorporated to manage and care for sufferers of age-related diseases such as chronic disease follow up, diabetes, heart disease etc. for the rural areas. This system provides a facility to the user to enter the medical information details. The proposed system generates a report related to patient health constraint and forward to the doctor. The doctor after analysing the data suggests either medicine or some further lab test, which is visible to the user. This will also be helpful for the advancement of medical research and analysis because this will make easy to follow up a patient's medical records.

In this context, we developed a dynamic web-based portal with an integration of sensor for rural area people health care monitoring named as “RAH Care”. In order to develop this customized real-time system we used prototype method, ASP.Net with C-Sharp(C#), JQuery, CSS and Ajax for interfacing with sensor and SQL Server as back end.

II. Related Work

The literature review brought to the fore circumstantial issues and brief historical overview of hospital information systems. Electronic Hospital Service Management System is increasingly becoming an emerging tool in healthcare arena to efficiently enable delivery of high-quality health services. Bakhshi et.al [13] discussed infrastructure, system practices, hindering and motivating forces behind hospital information system. Srbije [14] discussed various module to manage hospital service electronically in order to gather patient details efficiently which provide ease in rendering health services. Musa et.al [15] explained the challenges existing in hospital management systems related to operational efficiency and wait times among various processes belong to departments and persons. M.et al [16] conducted a study to evaluate the hospital information system (HIS) software based on user requirements in Iran. S.et.al [9] explained healthcare service has a vast opportunity in both direct and non-direct care settings. Organizations that provide care directly to client comes under direct care settings while the products and services available for direct care settings come under non-direct settings. Ouma et.al [17] discussed strategic decision support systems and clinical documentation systems related to Web Based Hospital Management Information Systems. Motta et al [18] discussed design and implementation of proper models for authorization and access control of electronic patient record (EPR). Hu et.al [19] explained the challenges of Hospital Information Systems facing in day to day medical task and provides a way to improve quality of service. T.et. al [20] reviewed the business case for an inpatient electronic medical record system by mentioning quantifiable benefits. Balaraman et.al [21] highlighted the issue of reliable storage and retrieval of data, networking and data exchange for Hospital information systems is important for efficient performance. However researcher in the past [14, 15, 17] addressed the issues associated with the current system but still, it needs customization for providing efficient service. Further messaging system for the next appointment not addressed in the past. Therefore, in this regard, our proposed system will provide dynamic platform to a registered patient to make online appointment with the doctor, get medical advice and follow up, customized message for next appointment in addition to another day to day medical facility. Existing studies with wearable sensors offer monitoring in applications like physiological, biochemical, and motion sensing [22,23,24]. Further during the study [25, 26] discussed body positioning with the help of sensor. [27, 28] explored the use of wearable sensors in cardiovascular, neurological, asthma, and hypertension diseases.

2.1 Problem with Existing System and Proposed Solution

The existed system only helps the Hospital management but is not useful to the patient out of the hospital in remote areas. So, the existed system is not useful for the people in remote areas where proper medical facility is not available. This system will provide an ease for incident reporting and proper taking care of patient living in far remote areas.

In case of some critical situation medical record of the patient is highly demanding. But it is quite difficult and sometimes impossible to access the medical history of the patient quickly and efficiently. By means of online appointment, consultation with a doctor, getting clinical advice, the availability of report of the clinical test and finally getting prescribed medicine by the doctor will bring ease of getting treatment.

2.2 Advantage of the system

- Incident reporting is easy by means of user friendly interface and wearable sensors
- Structured data entry for reporting the facts
- Easier and faster monitoring and sharing of information by several member
- No additional work of entering paper based information into database
- Easy and secured access for registered user

III. Material and Method

3.1. System Architecture

We have developed Web Based Hospital Service Management and Incident Reporting System taking care of health for the people of remote areas, named as EHSMIS. Waterfall method used for the development of EHSMIS. Unified Modeling Language (UML) ver. 2.0 used for this waterfall model. In the implementation phase 3-tier architecture named as a Presentation layer, Business layer, and Database layer used to develop the EHSMIS. SQL Server used as a backend to maintain the records in the database.



Figure-1: Architecture of RAH Care

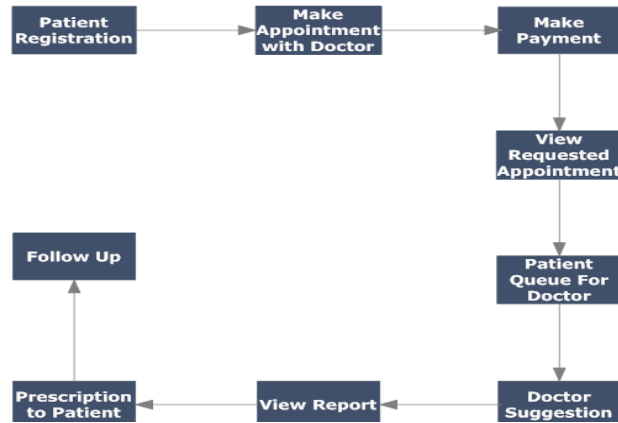


Figure-2: Architecture of online appointment and follow up for RAH Care

Object-oriented programming language C# used with ASP.Net as a front end. SQL Server is a Relational Database Management system (RDBMS) used for managing input from the patient, doctor and other concerned people. For developing responsive user-friendly web pages used Hypertext Markup Language (HTML). Interfaces developed and implemented using ASP.Net, CSS, and HTML with the support of C# and SQL Server. We used ASP.Net with C# in order to manage navigation link, manipulate pages, manage relational databases storage functions, to process queries with interfaces. SQL Server used to create and connect relational tables to the database. White-box and black box used to test the functionality of each module.

RAH Care system architecture consists of three tier. First tier consists of multiple wearable sensors for collecting medical information of patient. Second tier has the Web Interface for uploading this data into server. The third tier is the Web Portal. First tier provides the real time data by means of wearable sensor to second tier. This second tier has the Web interface. It has the ability to communicate with Web Portal via GPRS, 3G, 4G or other Wi-Fi networks through which user enter the medical information of patient such as Glucose level, weight, body temperature, Blood Pressure, Heart Rate. Finally it uploaded to server and doctor can view this information. The doctor gets an alert message with each upload. After viewing the patient data doctor will give suggestion and it will be available in the user interface. After analysing the patient data doctor can track the patient location by means of GPS facility embedded with this application and can decide to visit the patient or call in case of emergency.

During this case study, Zephyr BT wearable sensor used to extract heart rate information of the patient. Gluowise is needle free blood glucose measuring device based on sensor. Gluowise used for measuring Sugar level. Omron Wireless Upper arm B.P monitor used for blood pressure measurement. GPlus temperature sensor is used for measuring body temperature.

3.2. System Requirements and Design

The functional requirement of “RAH Care” is centered on the interaction of admin, patient, doctor and lab assistant. In this context, the interaction among admin, patient, doctor and lab staff modeled by means of use case diagram as shown in Figure (3-6), respectively.

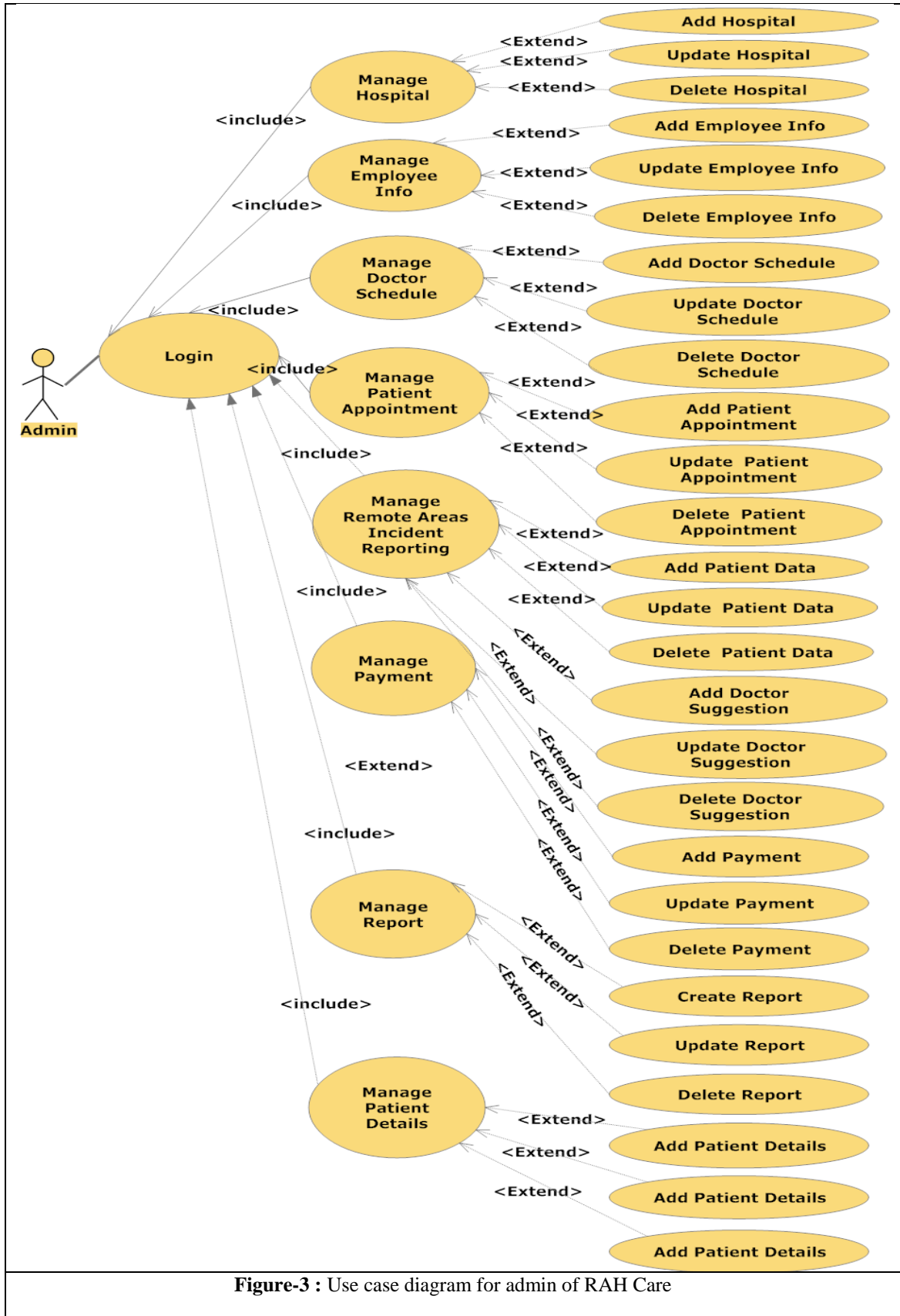


Figure-3 : Use case diagram for admin of RAH Care

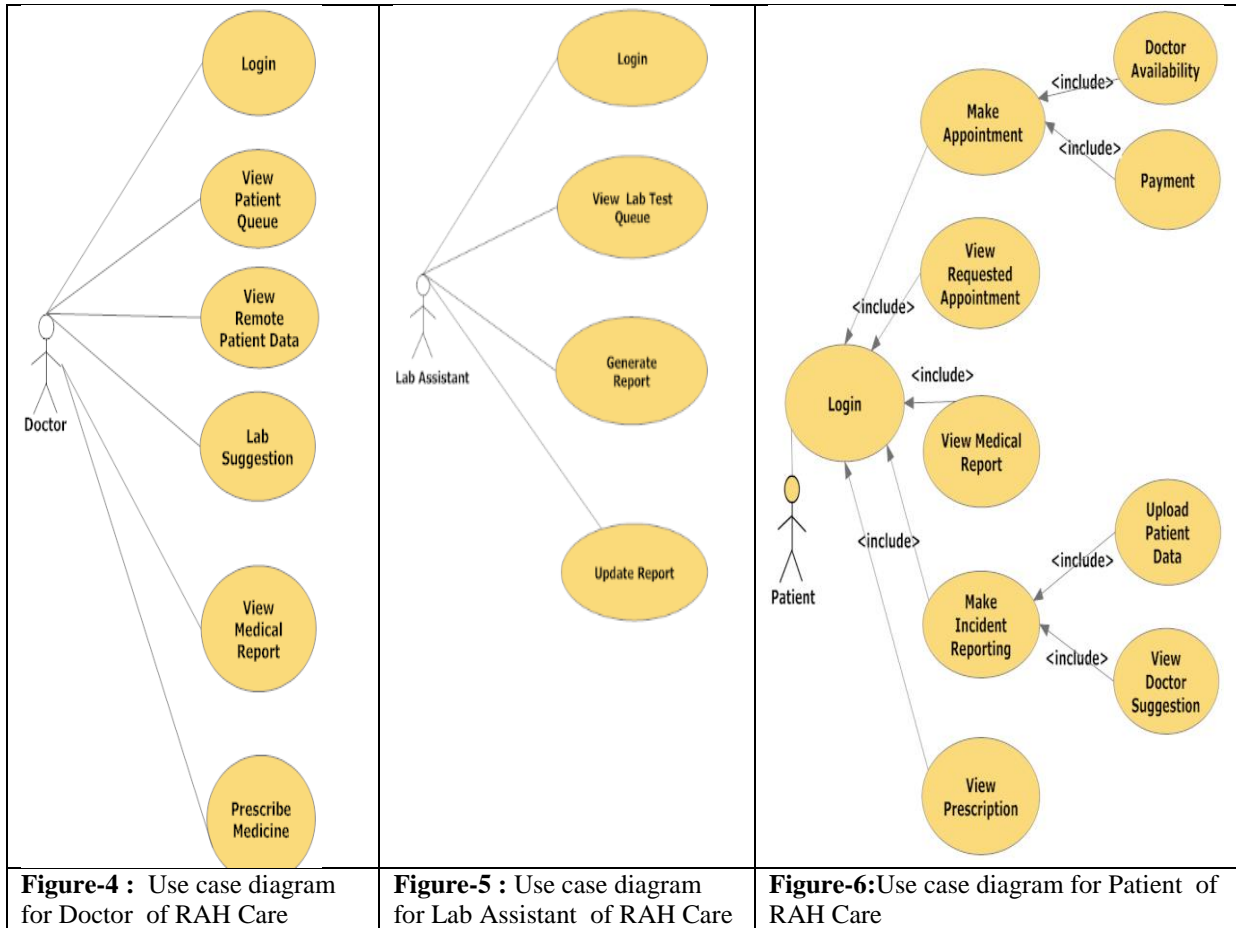


Figure-4 : Use case diagram for Doctor of RAH Care

Figure-5 : Use case diagram for Lab Assistant of RAH Care

Figure-6: Use case diagram for Patient of RAH Care

It is evident from the use case diagram of RAH Care that it has four actors admin, doctor, patient and lab assistant and 25 use cases. The actor admin of RAH Care after successful login can add and manage (edit/update/delete) employee information, patient details, doctor details, rural areas patient data, personal information, and reports. The actor doctor after successful login can view remote areas patient data, patient queue of online appointment, give suggestion to a patient, view the medical report and prescribe medicine. The actor lab assistant after successful login can generate a report of a lab test. On the other hand, the actor-patient after successful login can make an incident reporting from the rural areas, an appointment with a doctor, view the previous appointment, view doctor suggestion, view prescribed lab test and make payment.

Table 1. Use Case Actor Description

Use Case	Actor	Description
Login	Admin- Patient Doctor – Lab Assistant	Allow admin, doctor, patient and lab assistant for login after verification from username and password.
Manage Employee	Admin	Enable admin to manage the employee details
Manage Patient	Admin	Enable admin to manage patient details
Manage Doctor	Admin	Enable admin to manage Doctor details
Manage Report	Admin	Enable admin to manage report
Manage Payment	Admin	Enable admin to manage payment details
Manage Incident Reporting	Admin	Enable admin to manage medical info of the rural areas patient data
Manage Appointment	Admin	Enable admin to manage the appointment details
Register	Patient	Enable visitor to register in the system
Incident Reporting from remote areas	Patient	Enable Patient to report an incident from the rural areas
View Lab Report	Lab Assistant	Enable Lab Assistant to login in the system
Appointment with Doctor	Patient	Enable patient to make appointment with the Doctor.
Doctor Availability	Patient, Admin	Enable admin and patient to view the doctor availability
Doctor Suggestion	Doctor	Enable doctor to give suggestion to the patient
Pay Bill	Patient	Enable patient to pay bill
Prescribe Test for Patient	Doctor	Enable doctor to prescribe medical test to the patient
View Medical Report	Patient, Admin	Enable admin and patient to view the medical report

3.3.Activity Diagram. After use case, we created Activity Diagram for admin, doctor, patient and Lab assistant. The activity diagram explains the activity associated with each actor in RAH Care. Figure(7) represents the activity diagram for admin where the admin will log in with a unique username and password after that he can manage (edit/update/delete) employee details, doctor details, patient details, appointment details, view reports and payment details. Finally, admin can logout. Figure(8) illustrates the activity diagram for the doctor where a doctor will log in with their credentials(username and password) after that he can view patient queue, prescription history, medical report and update personal details and finally he can log out. Figure (9) shows the activity diagram for Patient. After successful login patient can upload medical information obtained from the sensor to a server, make an appointment, view the appointment history, consult the doctor, view prescribe test, view prescription of medicine and follow up with the doctor online. He can make payment and view the payment details. Also, he can update the personal details and finally can log out. Figure 10 illustrates the activity for Lab Assistant. After successful login, he can view the doctor suggestion for the medical test of the respective patient. He can perform the medical test of the patient and generate a report and finally can log out.

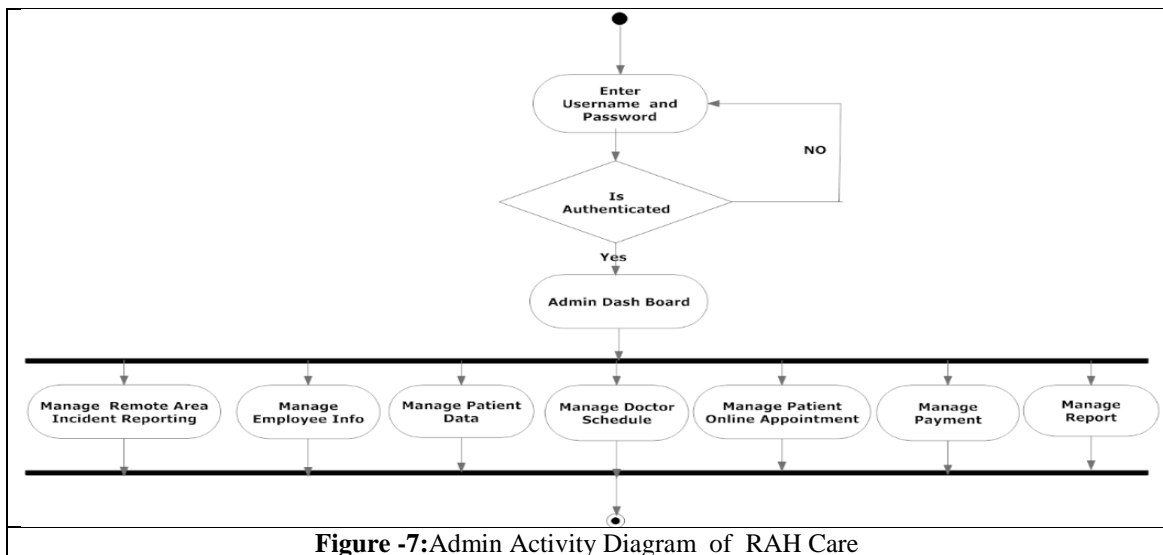


Figure -7:Admin Activity Diagram of RAH Care



Figure -8:Doctor Activity Diagram of RAH Care

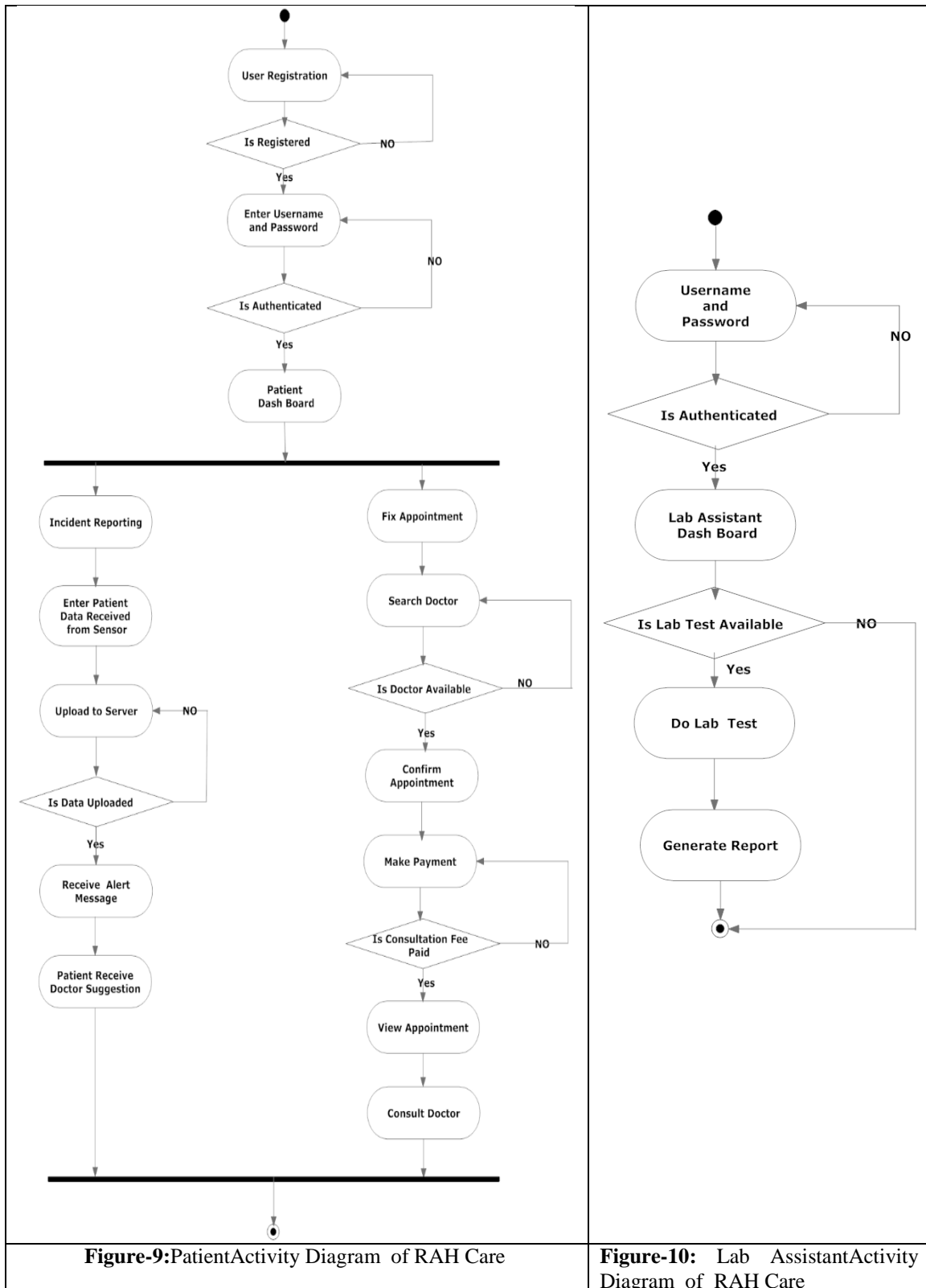


Figure-9: Patient Activity Diagram of RAH Care

Figure-10: Lab Assistant Activity Diagram of RAH Care

IV. Implementation

4.1. Interfaces and Visualization. An interactive user-friendly web interface of RAH Care designed to assist the user to navigate the different modules according to their role and privilege. The web page of RAH Care is categorized into four modules admin, doctor and patient and lab assistant module respectively. Figure-11 represents the admin module, after successful login, admin can manage (add, update, delete) the details of a hospital, employee, doctor, doctor schedule, patient, patient appointment, payment. Figure-12 represents the

doctor module after successful login doctor can view the patient appointment list using this link. Similarly, Figure-13 represents the patient module, after successful login patient can request a new appointment, view the requested appointment, view suggestions were given by a doctor, and view the prescription and can follow up the doctor from anywhere online.

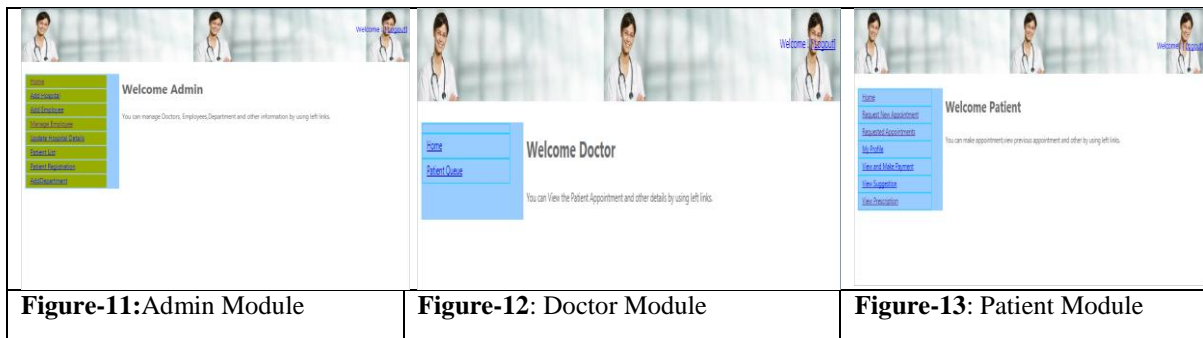


Figure-14 represents the patient registration page where a user can register themselves and get his credentials for login. Figure-15 represents the new appointment request page. Registered patient after successful login can search the desired doctor and his availability and fix an appointment. After that, he can consult with the doctor. Figure-16 represents the appointment history of the specific patient. Figure-17 represents the patient queue information page for the corresponding doctor. The doctor after successful login can check the appointment details of the patient. Figure-18 represents the suggestion page where the doctor can give suggestions to the patient which is available online for the patient. Figure-19 represents the prescription page. The doctor can write prescribed medicine to the concerned patient after viewing all medical reports and the user can view it globally.

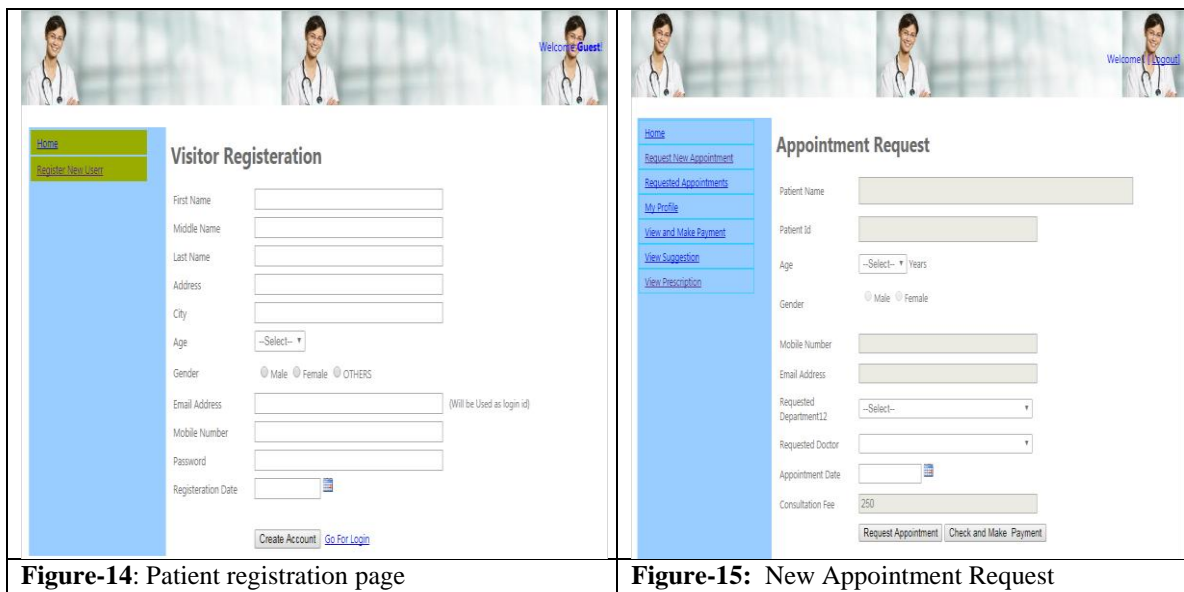




Figure-16: Appointment History



Figure-17: Patient Queue for specific doctor

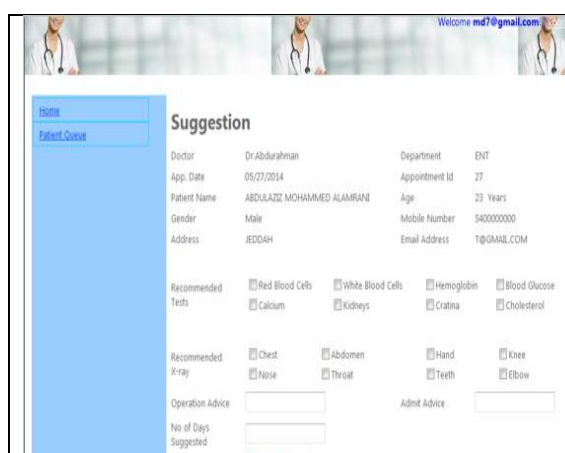


Figure-18: Doctor Suggestion page

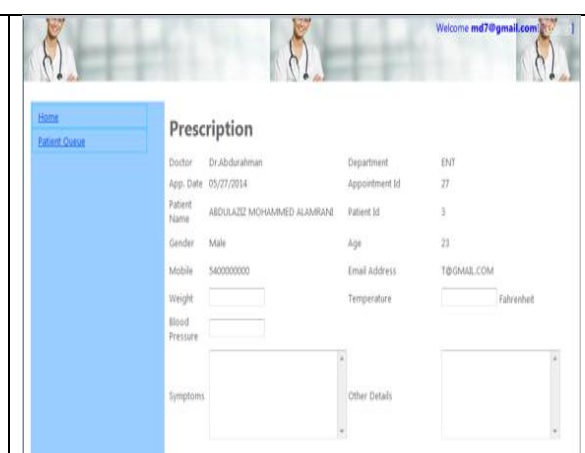


Figure-19: Medicine Prescription

4.2. Case study:

The proposed approach is applied to a rural area AL-ABWA, SAUDI ARABIA

This case study presents a rural area healthcare monitoring using the World Wide Web infrastructure with an integration of sensor technology. The data is stored in the server and it can be accessed from anywhere through the internet.

A wide range of health data such as weight, blood pressure, blood sugar and heart rate collected during the study by means of sensor. In case of any abnormal condition the data is recorded and uploaded to server by user. Once uploaded successfully the doctor gets an alert message. Most of the time by means of this system people get proper treatment. Further, health professionals monitor these patients remotely and act on the information received as part of the treatment plan.

V. Discussion

This RAH Care provides an ease to the user. Various sensitive parameters such as Blood Pressure, Body temperature, Pulse rate, glucose level etc. have been collected by means of wearable sensor and transmitted to GUI. This finally uploaded to the server. On the other hand doctor got this data on his interface with an alert message. The accumulated data is stored in the database server. Ultimately data of the patients living in rural areas become available to the specialist doctor in a multi-specialty hospital. This model can be accessed by administrator, patients and doctors/Medical personnel.

VI. Conclusion

Sometimes due to delay in diagnosis and proper treatment for the rural area people the situation becomes very critical and leads to death also. This system is very helpful in diagnosing and treating the patient and can solve the issue to a great extent. In addition, this system provides ease to the user to make an online appointment with a doctor, follow up with the doctor, view medical reports, view prescribed medicine by the doctor and get the prompt message for the upcoming appointment. This portal will help the patient by providing

a better coordination with doctors and another concerned person. And thus we achieve the desired result in term of service, quality, and profits comparatively.

6.1. Future Work. This paper can be extended in future by integrating Wearable Sensors with Web as well as an Android for RAH Care and the data transmission will be made automatically in the extended work. The delay in the alert message will also be considered.

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A contribution of authors. Both authors have contributed equally in designing of the system as well as in the preparation of the article.

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