PalArch's Journal of Archaeology of Egypt / Egyptology

NFC-MEDMANAGE: PHARMACY AND MEDICATION MANAGEMENT USING NFC TECHNOLOGY

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ABSTRACT

Saudi Arabia and most countries in the world suffer greatly from excessive drugs that are not used after obtaining greater quantities of needs miscalculation waste of medicines and follow-up history. A study by the clinical pharmacist in the department of oncology and hematology in the national guard health affairs found also that "there is a waste of drugs estimated at 500 million riyals annually, and the budget of medicine in the Kingdom is estimated at six or seven billion Riyals annually [2], [17].

Therefore, our project NFC-MedManage aims to minimize the huge waste of medicines and to reduce the problems of medication dispenses and waste in pharmacies. The proposed system uses NFC enabled smartphones and each medicine packet is tagged by NFC tag, which contains all medicines information and saving its details in the database. Pharmacists scan each medicine before storing it in the pharmacy inventory to list and count each medicine in the pharmacy. After that, pharmacists can scan each medicine tag before giving it to a patient to ensure its validity in terms of expiry date and package status. By doing so, pharmacists can check medicine validity in a short time. Suppliers are also able to have a quick automatic overview of each pharmacy status in terms of medicine wastage and inventory shortage. This application helps pharmacists to manage medicines and follow-up periodically and help supplier companies to follow pharmacies and improve distribution methods and expected production ratio. It also helps the company to efficiently track the damaged medicines and manage the pharmacy waste containers by getting rid of damaged medicines better.

INTRODUCTION

Technology has become an urgent necessity; it has facilitated human life in general. It has given our lives a variety of ways to enable us to deal with its various problems and has contributed to the provision of more quality services for us at lower cost, time and effort. Besides, technology has now become an essential element of the workplace that means the works without support from technology may likely be unsuccessful. One of the simplest examples of what technology offers it's making our works more efficient, where they allow staff in any sector to be more productive and efficient, and more exact. It has made communicating for any purpose more effectively and has become easier, faster than ever [1], [19]. Currently, we face some problems in the field of pharmaceuticals in the health sector such as medicine wastage. There is a waste of drugs estimated at 500 million riyals annually, and the budget of medicine in the Kingdom is estimated at six or seven billion riyals annually [2], [17].

Pharmacist Abdulrahman Al-sultan in the committee of scientific offices of pharmaceutical companies and the director of governmental and public relations at Al-Jazeera pharmaceutical industries declared that some causes of or medicine wastage are the weakness of pharmaceutical procurement programs in the governmental sector [2], [17]. We live in the age of technology and the purpose of this project is to free the field of pharmaceutical in the health sector of the following problems:

1. Limitations exist in traditional methods of dispensing medication.
2. Poor planning and management.
3. Lack of knowledge of the actual need.
4. Sudden inventory shortage.
5. Workload.

Through technology, specifically mobile applications, we hope to solve this problem by developing an application running on the android platform, which is called NFC-MedManage application. It aims to provide a connection between the pharmaceutical suppliers with pharmacists using NFC technology. The NFC technology is used to facilitate the supply of medicines to the stores or pharmacies in a technical manner and reduce the waste of medicines and unknown shortages previously in stores inventory. Each medicine packet is tagged by NFC tag, which contains all medicines information and saving its details in the database. Pharmacists scan each medicine before storing it in the pharmacy inventory to list and count each medicine in the pharmacy. After that, pharmacists can scan each medicine tag before giving it to a patient to make sure it's valid in terms of expiry date and package status. By doing so, pharmacists can check medicine validity in a short time by just tapping the NFC tag. In addition, suppliers can have a quick automatic overview of each pharmacy status in terms of medicine wastage and inventory shortage. These help suppliers carefully manage-medicines distribution and minimize the cost spent on dispensing. The structure of the paper is as follows; the first section introduces the feasibility study and its results to verify the feasibility of this project in the scope allocated to it, we present the problems and objectives of the system and the benefits that achieve after its implementation. In section 2,

related work is discussed with a comparison with the proposed idea. Section 3 provides a general description of the concept of the system and the methodology used in its implementation, in addition to describing the requirements to be achieved in support of the main system objectives, also described aspects of system design such as the database design, system process design, also designed the initial prototype of the application interfaces that display the most important services to users has also been completed. Section 4 shows the implementation phase it contains the app interfaces for both users. Finally, Conclusion and future work are presented in section 5.

Problem statement

Saudi Arabia and most countries in the world suffer greatly from excessive medicines that are not used after obtaining greater quantities of needs miscalculation waste of medicines and follow-up history. In the field of pharmaceuticals in the health sector "there is a waste of drugs estimated at 500 million riyals annually, and the budget of medicine in the Kingdom is estimated at six or seven billion riyals annually [2],[17]. In addition, traditional methods of dispensing medication suffer from several limitations, which are:
1. Huge efforts are required to complete traditional dispensing methods
2. Poor planning and management.
3. Lack of knowledge of the actual need.
4. Sudden inventory shortage.
5. The huge waste of medicines.

Scope of the project

This project aims to establish a link between the pharmaceutical and the pharmaceutical supplier using the NFC technology application for mobile phones. The app is for Android-based systems. The target user of the system is the pharmaceutical and pharmaceutical resource in the health sector. Each of them has a different interface that includes many services to facilitate and organize the management of the supply of medicines to the stores in a technical manner and reduce the waste of medicines and a previously unknown deficiency in the inventory of the stores. Through this project, we have managed to solve the mentioned problems in the field of medicines in the health sector.

Project objectives

Our project aims to achieve the following objectives:
1. To supply medicines to pharmacies easily and technically instead of the traditional methods.
2. To reduce the percentage of wasted medicines.
3. To save time and effort when requesting medicine from the company.
4. To solve the problem of the survival of damaged medicines and accumulation for a longer period, in the pharmacy.
5. To solve the problem of interruption of the drug and sudden inventory shortage from pharmacies for a period.

6. To solve the problem of dispensing medicines expired to patients.

7.To follow-up with the company to medicines and to see the damage and deficiency continuously.

8. To reduce time, spend manually ordering

Medicines.

Our system benefits

1. Reduce the material costs of distribution medicines
2. Management of medicines in an organized manner
3. Quicklyget medication information in pharmacist's language
4. Lack of any medicine in the pharmacy store
5. Easy to follow
6. Avoid sending an unnecessary medicine to a pharmacy
7. Manage the damaged medication properly and orderly
8. Reduce workload.

LITERATURE REVIEW

In this section, we discuss some related projects that proposed to perform medicine dispensing and management tasks. That facilitates understanding our project in comparison with existing projects.

Related work

In the process of building a successful supply chain management, many decisions need to be taken. These decisions are associated with three aspects, which include information flow, product, and funds. The purpose of building an automatic supply chain management is to increase the whole supply chain profitability and quality.

In 2015, Hospital Supply Chain Management System (HSCM) was presented by Firouzi et al. to be a new approach. This approach integrates all components of hospital which include suppliers, services rendered by hospitals, transport system and medical facilities all in one system in order to optimize all used resources in health care system to create Total Quality Management (TQM)[2],[17]. The system has proven successful in several aspects including high reduction rate of the inventory, a high increase in on-time delivery and inventory returns [2],[3],[16].

Utama et al. also introduced a pharmacy monitoring system as an application on smartphone devices which uses electronic sensors that are linked to an Intel Galileo board to inspect the temperature of refrigeration in pharmacy. This application includes two subsystems, which are drug distribution subsystem and the temperature control subsystem. In the drug distribution subsystem, a database is used to record all the information related to medicine such as the quantity of each type of medication. In the temperature control subsystem, a temperature sensor is used to completely monitor the room temperature and presented through the GUI (Graphical User Interface) The purpose of the mobile health application is to track medicines and medical devices in

healthcare units in Indonesia [4]. In their study, they stated the limitations to include a variety of mobile devices in Indonesia, poor infrastructural development in some areas, as there are places that are only covered by 2G mobile technology. The proposed application requires special skills [4] as it enhances remote response to the requirements and queries of supply chain systems regardless of the location and infrastructure.

It also uses Graphical User Interface (GUI), which is more accessible for users. Moreover, the application reduces the rate of errors by using electronic sensors to track changes. However, the problem with this solution is that it relies on nodes that are complex and thermometers depend on hesitant power connectivity and lastly scaling the solution to hundreds of nodes is expensive.

Another study introduced a model and algorithm to improve the distribution and management of resources for disaster missions. The study considered four stages of Supply Chain Network (SCN), these include far supply node, local supply node, satellites (small warehouse), and customers (very small warehouse), the problems were however categorized based on the following: transportation mode, routes, demands, inventories, traveling time, load/unload times, distances, and costs. The model was programmed and optimized using Gurobi software [5]. The advantage of the system is that it integrates inventory management in the multi-echelon process, multiple realistic problems was also considered simultaneously, these included multiple products, heterogeneous fleet, and multiple periods.

Another system uses the Arduino Mega 2560 processing board with Atmel 2560 microcontroller and RFID tags. It gathers all information from peripheral equipment and then store into a database [6]. The purpose of the system is track users' actions, such as placement or displacement of medicine. This enhances the system to have the capacity to monitor all actions toward medical objects. The proposed system uses a database to store the gathered information [6].The main advantages of the automated system are that computer-based systems with GUI are easy to use by physicians and nurses, and cost-effective. However, the system suffers from some critical limitations, in that it has only two load cells, hence, there is need for an expansion in order to support a larger number of medications.

Another proposed methodology called OPRI (Objectives, Parameters, Risk, Indicators) is used to build a medicine supply chain dashboard for public hospitals. This methodology is based on process modeling using SCOR (Supply Chain Operations Reference), ARIS and risk analysis.

The proposed system has been used in in a public hospital in Morocco and one of it is advantages is that it enhances purchasing centralization [7].

In a recent study carried out by Han et al., web-based information system was designed with the support of sensors for drug dispensing to assist pharmacists in their work [8]. The proposed system is based on two parts, which are notification and monitoring processes. The key purpose of the proposed system

is to eliminate time taken for dispensing drug as well as minimizing the rate of errors that might occur during drug dispensation as most drugs' boxes are similar. The system uses LED notification to notify pharmacists about the correct cabinets for the needed drug. In addition, the system uses infrared (IR) sensors to track a pharmacist action which is done by alarming in case any mistake occurs while dispensing drugs [8]. The cost of the system is effective compared to other proposed systems.

In 2018, Abidin et al proposed a system using Radio Frequency Identification (RFID) and NFC technology in the healthcare system [9]. The system aimed at monitoring the expiry date of medicines. Each medicine objects are attached with RFID tags. The system also uses NFC technology to secure the system and prevent harmful actions. The main advantage of the proposed system is that it is very affordable compared to other proposed systems, however, there is need for more improvements in the security part of the system.

McKesson Scan Manager is a barcode system developed to supply medicines and to allow staff to create order to the location desired by the users. This system is easy to use, increases efficiency and saves time, but users discovered that the medicine names are confusing and difficult to learn [11],[12]. In the same vein, users revealed that duplicate medicines often bring about difficult in scanning and poor error tolerance. In 2004, Patterson, Rogers and Render as well as ASHP reported the drawbacks of barcode systems to include large investment Workarounds and downtime Malfunctioning equipment.

Many studies have been carried out to automate healthcare services such as hospital management and drugs dispensing using a web-based application. The advantage of using web-based application is that there is simplicity in the implementation of the web applications through a pre-existing information system in the hospital. In addition, patients only need to use a web browser in order to access the system [10]. Several studies showed the advantages of using automatic health services to include the reduction of clinical risks, optimization of all working process, as well as the provision of more care and attention to the patient. Thus, building an automatic system will help to monitor the expiry date and the status of medicine as well as eliminating dispensing errors [14],[18],[21],[16], [23], [24], [25],[28].

Provider pharmaceutical order

The traditional method used to request medicine in Saudi Arabia is filling papers, which include the name of the medicine and the number of products as shown in Figure 1.
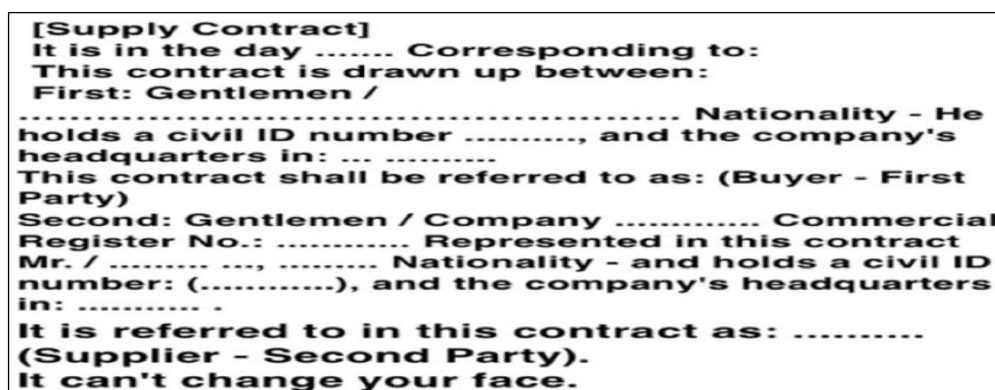
Figure 1: Requesting Letter for Medicine Supply in the Traditional System

This model demonstrates the traditional way in which the medicine is ordered from the supplier by contract (see Figure 1).

Currently, Mawared is a web-based application used in Saudi Arabia for medicine dispensing and it allows pharmacists to request medicines once they have a shortage (see Figure 2).
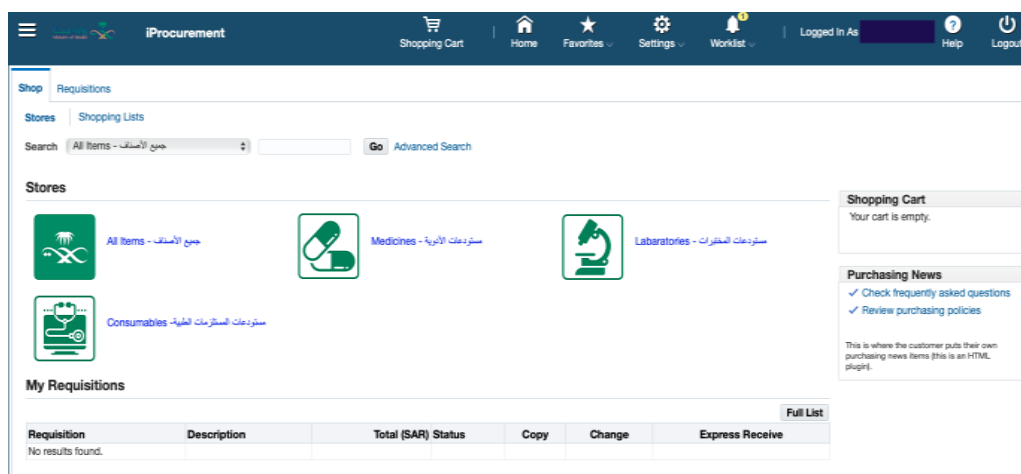

Figure 2: Mawared System

Mawared overcomes the limitations of the traditional methods where pharmacists should fill several papers to request medicines. However, it still suffers from a set of limitations, which are time consuming as it requires pharmacists to follow several steps to require one type of medicine. Another limitation is that pharmacists might forget to request a medicine, which leads to a sudden shortage of medicine.

Comparison between IoT used NFC technology

By considering the procurement methods and techniques used in the procurement and the proposed NFC system, we found some differences (as shown in the Table 1).

Table 1: Comparison between techniques used in supply management Techniques RFID Barcode QR NFC

Techniques	RFID	Barcode	QR	NFC
Storing data	Yes	No	Yes	Yes
Cost	low	low	low	low
Time	short	short	short	short
Ease of use	Yes	Yes	Yes	Yes
Speed	fast	fast	fast	fast
Requiring other equipment	camera	camera	camera	none
Requiring precise direction	Yes	Yes	Yes	No

Table 2: Comparison between some supply medication system

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Features	Mawared	Traditional	MedManage
Minimizing error rate	No	No	Yes
Less effort	No	No	Yes
Effective cost	Low	High	low
Time	Long	Long	short
Usability	No	No	Yes
Showing quick report	No	No	Yes
Less paper work	Yes	No	Yes
Few steps to complete	No	Yes	No
Adequate medicine info	No	No	Yes

Rison between supply medicines methods

By looking at the methods used in the supply of medicines and the Med-Manage system we found some differences (as shown in the Table 2)

Comparison between NFC tags and QR codes

Differences between NFC tags and QR codes based on some criteria are discussed in the section below [15], [26], [27], [29].

1. The cost of QR codes is related to the cost of printing and distribution processes. The cost of printing QR codes is based on the volume and size of the codes, while the cost of the NFC technology is associated with the price of the encoded chips.

2. Interactions with NFC tags are easier and more comfortable than QR codes. With the use of technology on smartphone devices, NFC tags can easily be tapped. QR code on the other hand requires users to use their smartphone devices' Cameras to scan a QR code, which requires proper lighting and precise direction to correctly read the content of the QR code.

3. Availability: recently, NFC technology is supported by most smartphone devices. Moreover, many services, such as payment and transportation are using NFC technology as an essential tool for digital transactions. Similarly, the people can create QR codes and make use of them for a particular purpose.

4. Customization: NFC tags can be customized based on a user requirement. NFC companies makes it possible for customers to completely hide the NFC tags, while the QR code does not provide options for customization as it needs to be visible and the color to be used must be very dark so that the device can easily read the content.

5. Security: NFC technology discourages hackers from reading its content by minimizing communication range between the reader and the tag, which is approximately 4 centimeters. It also encrypts its content for payment transactions to provide more protection for data while QR codes does not protect its content and it can be scanned by anyone without protection.
6. Changes in Post-production: NFC tags can be used several times and can be rewritten while, QR code does not allow any modification after being published.

SYSTEM ANALYSIS AND DESIGN
In this section, we presented a general description of the system and mentioned the methodology used to implement it. In addition, the software and hardware requirement. Also, we mentioned all types of software design that used in the system implementation phase.

System description

This section shows how the system works and implements by two sides the Supplier Company and pharmacy (see Figure 3). First, the supplier company and the pharmacy install the application on their phones and then they create an account in the app by using their email and new password. It has two different interfaces. From the pharmacist interface the home page shows many icons.

First, start checking the medicine by scanning the NFC tag marker of the medicine, after that, the information stored in the medicine is saved in the databases. By scanning the NFC tag of the medicine, it is displayed if it is valid for distribution (based on the expiration date and the package status if broken or opened If it is invalid it is added to the table of damaged medicines and thrown into the damaged basket. Second from the supplier company interface after registration in the application: The first screen that appears a map showing the pharmacy status, when you click any of the pharmacies shown on the map shows the pharmacy status provision of medicines, recovery of damaged

medicines if the pharmacy status has been verified successfully and The sidebar menu shows the services available in the application,(add pharmacy, delete pharmacy, pharmacy state, show all pharmacy). You can also see medicine dispensing statistics at each most consumed pharmacy and quantity of damaged medicines by clicking on the statistics box.
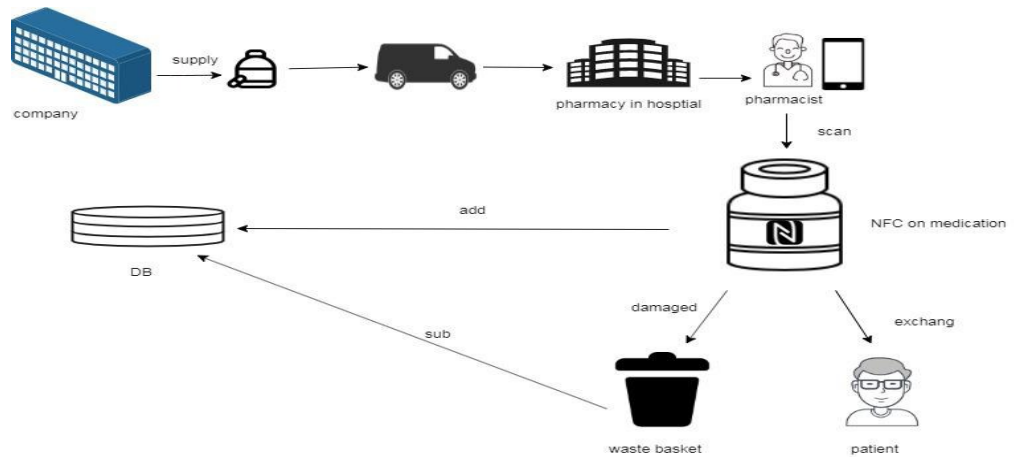

Figure 3: System Framework

Flowchart diagram

A flowchart is a schematic diagram showing all system processes sequentially in a hierarchical format where each step in the system is described separately in a shape specific to each process and refers to it and is linked together by arrows.
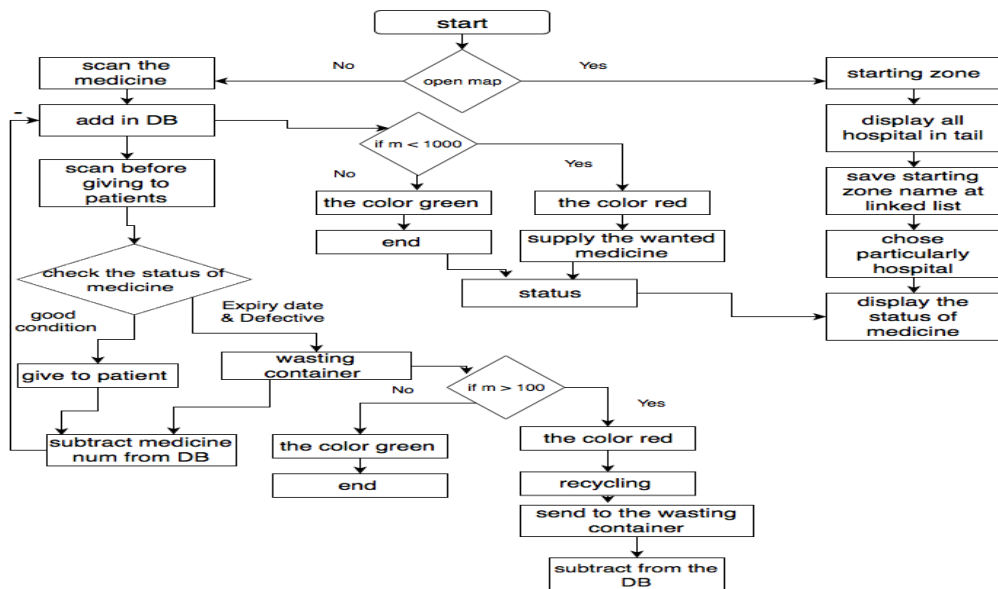
Figure 4: Flowchart Diagram

Figure 4 shows the NFC-Med Manage application steps in sequential order. This model is used in the system design and analysis process to help understand complex processes, collect data, identify problems and gather resources.

IMPLEMENTATION

Interfaces

In this section, we provide a general description of the implementation phase that includes how to produce the actual version of the application. we use Android Studio program to implement the application with the support of Java and PHP languages to connect the application with the database.

The start screen and the registration screen appear when you open the application, the user can select the type of user (supplier or pharmacy company) and then fill in the information fields (see Figure 5 and Figure 6). Pharmacists log into the Med-Manage app with their IDs and passwords. They start examining the medicine by clearing the medicine's NFC tag. By scanning the NFC tag of the medicine, it is shown if it is valid for distribution based on the expiration date and package status. If it is broken or opened, it means that it is not valid and it is added to the schedule of the damaged medicines and dumped into the damaged basket. After all medicines have been erased, medicine information appears (see Figure 8).

Pharmacy interfaces

Figure 5: Start Page

Figure 5 shows the interface that appears when starting the application.
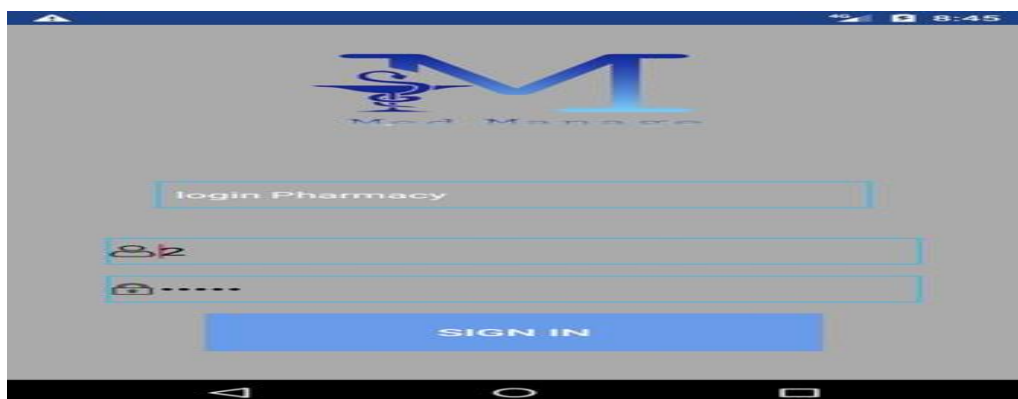
Figure 6: Sign in Interface

Figure 6 shows the application's login interface contains a spinner that determines whether it is addictive or pharmacy. The entry is made using a username and password and then clicks the sign in button.
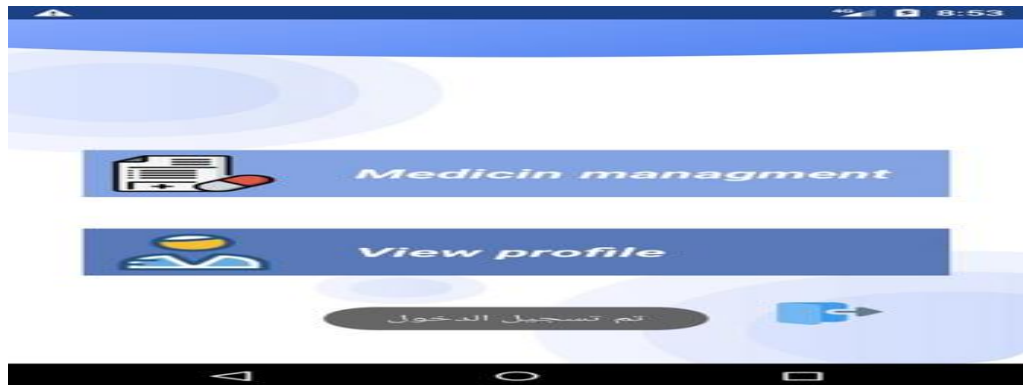

Figure 7: Home Page

In the Figure 7, After logging in from the pharmacy, the interface contains 2 buttons. The first button medicine Management through which the scan for NFC Tag affixed to the medicine packaging is displayed. The second button view profile that displays the pharmacy information, below the interface icon, to sign out.

Figure 8: Profile Page

In the Figure 8, after clicking on the view profile button, the pharmacy information is displayed: ID, pharmacy Name, Pharmacy Status, Pharmacy Recycle Number.
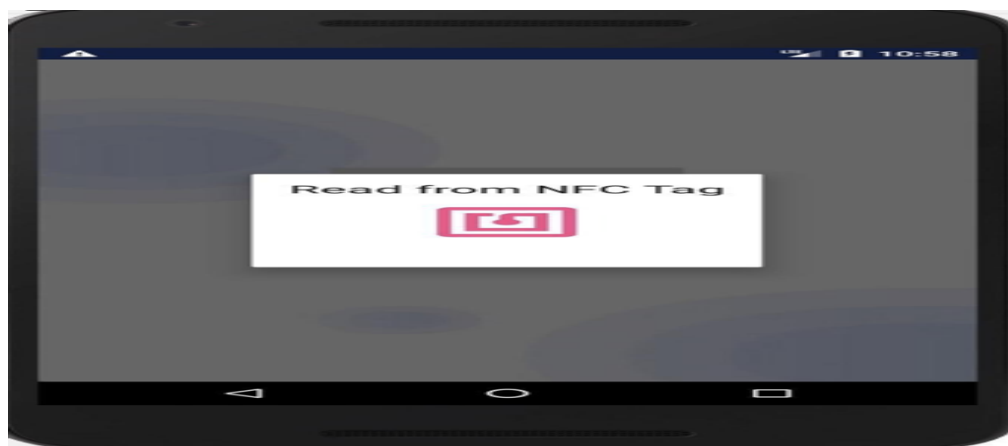
Figure 9: Scan Page

In the Figure 9, medicine residents worked with the NFC Tag affixed to the medicine packaging by passing the label on the Tag reader.

Figure 10: Information Medicines Page

In the Figure 10, After the Scan for medicine process, medicine information (ID, Name of medicine, description for medicine) is displayed in Edit Text, the amount of medicine is written, the parameter for medicine is determined by 3 buttons. The first button Add new medicine to the pharmacy inventory. The second button Add damaged drug to the container. The third button given medicine.

Application interfaces from the supplier side

The supplier company logins into the app using his ID and password (see Figure 11), after registration in the application: The first screen that appears in a map showing all pharmacies existing in the city and each pharmacy status. When a supplier clicks any of the pharmacies shown on the map (see Figure 14), the pharmacy status is displayed. Based on the pharmacy status, the supplier should deliver the shortage medicines and transfer damaged medicines in case the container is full. Furthermore, the suppliers can do the following functions,

which include adding pharmacy, deleting pharmacy, showing pharmacy state, showing all pharmacies (see Figure 14, Figure 15, Figure 16, and Figure 17).

Figure 11: Sign in Interface

In the Figure 11, the application's login interface contains a spinner that determines whether it is addictive or pharmacy. The entry is made using a username and password and then clicks the sign in button.
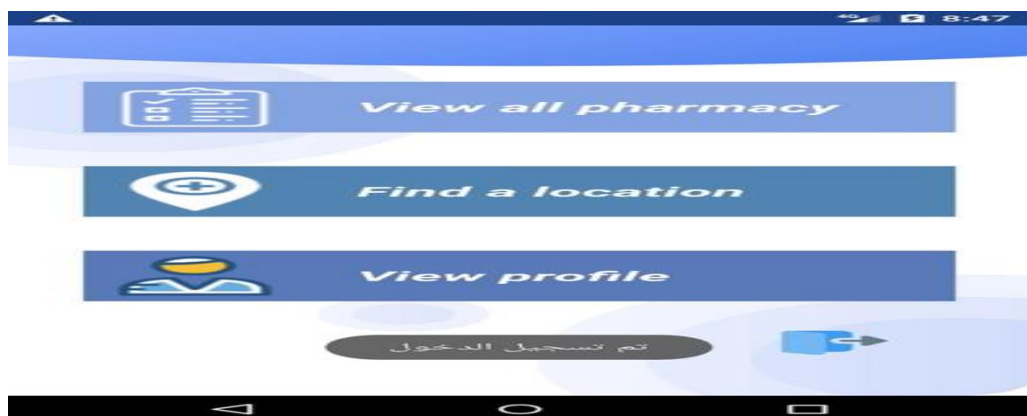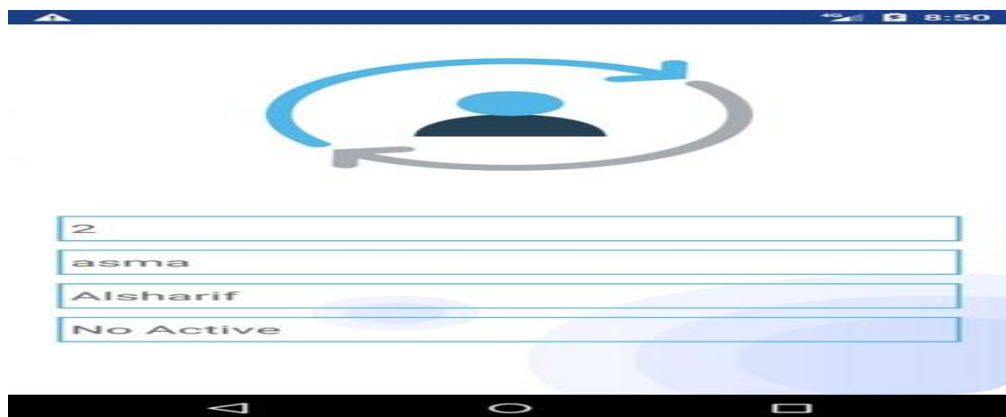

Figure 12: Home Page

In the Figure 12, After the login process on the Admin side, this interface consists of 3 buttons, the first button view, all pharmacies, the second button, Find Location, the third button, View Profile, below the interface icon, to sign out.

Figure 13: Profile Page

In the Figure 13, after clicking on the View Profile button, the Admin information is displayed (ID, first name, last name, Status).
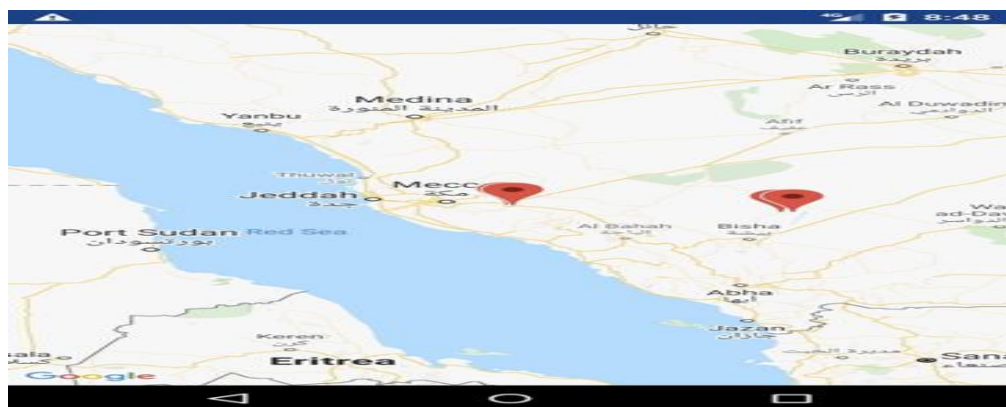

Figure 14: Find a location Page

In the Figure 14, In the map interface, the location of each pharmacy registered in the application is determined with the pharmacy requirement display (supplying medicines or empty containers).
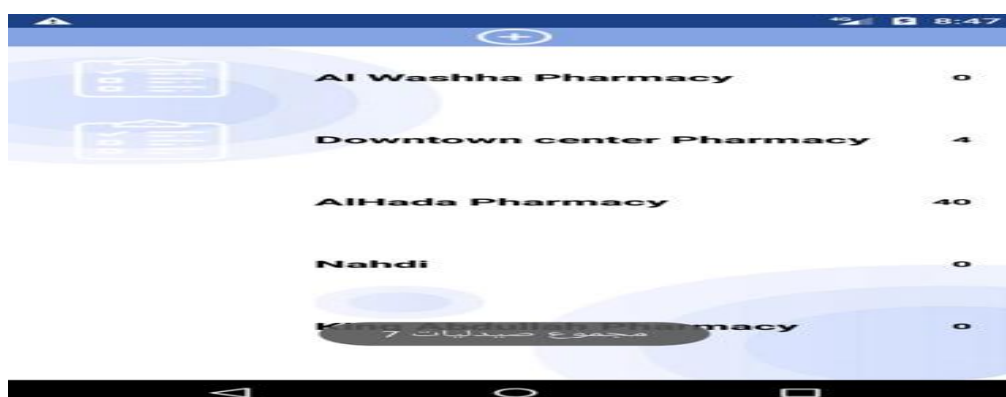

Figure 15: View All Pharmacy Page

In the Figure 15, when you click on the View all pharmacies button, the icon for adding a new pharmacy appears at the beginning of the interface, and all the pharmacies names registered in the system appear next to each pharmacy name. The amount of medicine available.

Figure 16: Add Pharmacy Page

In the Figure 16, When clicking on the add new pharmacy icon. The following fields are required (pharmacy name, user name, password, and re password) then click the Add button to add the pharmacy to the pharmacy list.
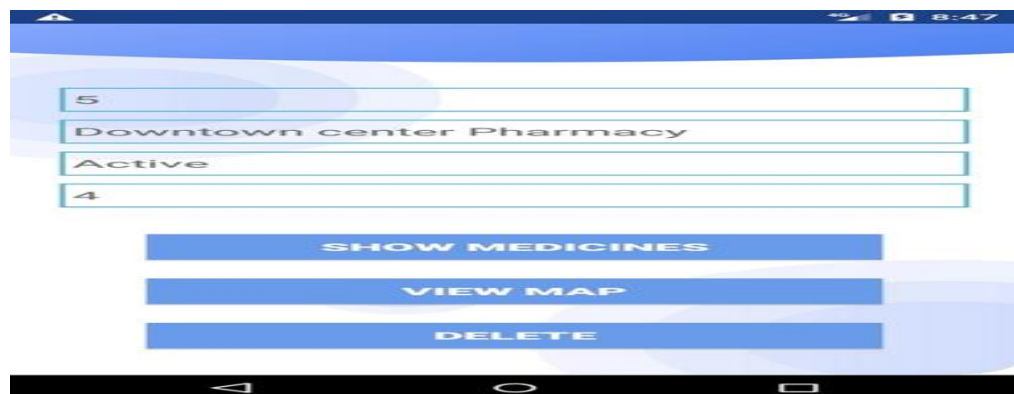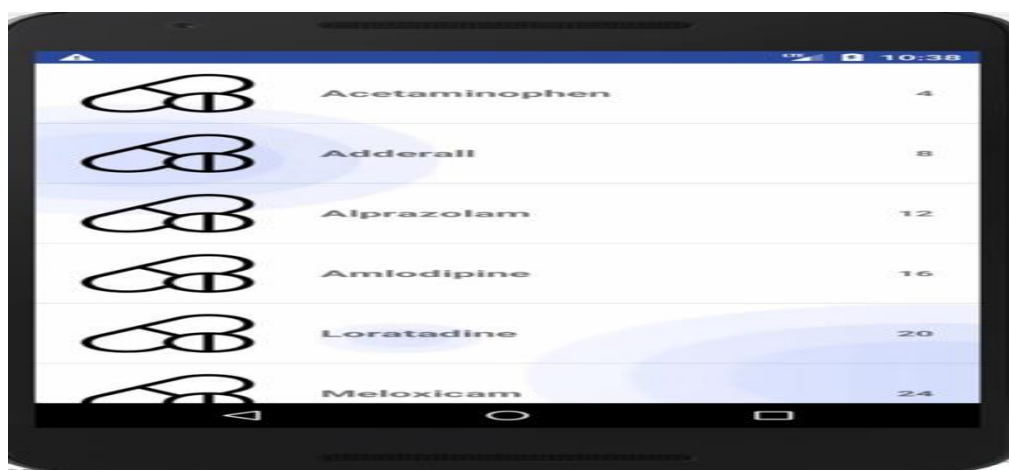

Figure 17: Information Pharmacy

In the Figure 17, when you click on a specific pharmacy, the pharmacy information (ID, name of the pharmacy, Status, number of medicines) also appears. There are 3 buttons. The first button Show medicine displays all the medicines in the pharmacy inventory. The second button, View Map, the third button, Delete, deletes the pharmacy information from the system.

Figure 18: Information Medicines Page

In the Figure 18, when pressing Show medicine, all the medicines available in the pharmacy inventory appear next to each medicine and the number of available quantities.

CONCLUSION AND FUTURE WORK

We presented a new medicine supply management system that aims to reduce the waste of medicines and unknown shortages previously in stores inventory as well as solving the problems mentioned in the field of pharmaceutical in the health sector. In light of the successful experiences that have been developed using NFC technology in the health sector, these results have allowed for a significant improvement in the quality of services using this technology. Thus, we used NFC technology to build an application that automatically links between pharmacies and suppliers. The links between the company and the pharmacy aim is to facilitate the supply of medicines and monitor the drug stock from a sudden shortage or accumulation of drugs.

NFC tag is attached to the package of the drug and when the medicine arrives at the pharmacy, the pharmacist makes a scan it and all the medicine info is stored in the database and notices appear on the map through which the company knows the need of each pharmacy and the damaged drugs and the company is automatically informed of the stock of the drug.

One of the main benefits of building NFC-Med Manage project is that it transmits data and receives it over radio waves very quickly, more safely, and is flexible that stores different types of information without the need to create a new NFC tag. While our research work concentrates mainly on solving medicines distribution systems, we believe that the proposed application improves the quality and management of the health system, for example, reducing pharmacists' work.

In the future, the system will be evaluated by conducting field studies and improving it based on users' feedback to determine its strengths and weaknesses.

We need also to provide the NFC-Med Manage application in both Arabic and English to cover a wide range of population. Enabling pharmacies in the military, government and private sectors to use the application as it extends to all regions of the Kingdom.

ACKNOWLEDGEMENT

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