

Designing and implementing an electronic health record (Ehr) for telemedicine purposes

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تصميم السجل الصحي الإلكتروني لخدمة أهداف الطب عن بعد وتنفيذه

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المستخلص

يتناول البحث الحالي مشكلة معالجة البيانات التي تعد من أعقد المشاكل في مجال الرعاية الصحية، حيث تعاني معظم المستشفيات والعيادات والمراكز والمؤسسات الصحية عدم توفر قواعد بيانات متينة قادرة على الحفاظ للتنوع الهائل لبيانات المرضى والحفاظ على تماسك هذه البيانات ولهذا يقدم البحث الحالي نظام السجلات الصحية الإلكترونية EHR.

الهدف هذا البحث هو تصميم وتنفيذ نظام السجل الطبي الإلكتروني على شبكة الإنترنت مما يساعد على خلق مستوع للبيانات الصحية سهل الوصول في أي وقت وبكلفة أقل وهذا ما يجعل أنتشار تطبيقات الطب عن بعد أهل في المستقبل . السجل الطبي الإلكتروني المقترح قادر على تخزين البيانات المتعلقة بالمرضى مثل المعلومات الشخصية ، تفاصيل العنوان ، التركيبة السكانية ، ملاحظات عن تقدم الحالة المرضية ، التحصينات ، البيانات المختبرية ، معلومات الأشعة ، التاريخ الطبي السابق ، التاريخ العائلي ، العلامات الحيوية ، تاريخ التدخين ، تاريخ الكحول ، الفحوصات وغيرها .

يضم نظام EHR المقترح مكونين آخرين هما نظام للاستعلامات يتم من خلاله جمع البيانات المختلفة من الجداول باستخدام عوامل برمجية رياضية ومنطقية ، يستخدم نظام الاستعلامات هذا يحاول الإجابة على أي تساؤلات مطروحة على من قبل الباحثين الأكاديميين. بينما المكون الآخر هو البنية الأمامية للنظام والتي هي عبارة عن مجموعة من واجهات الرسومية للمستخدم تسهل عمليات التعامل مع برمجيات النظام وتعمل كجسر بين المستخدمين والنظام .

Abstract

This research deals with the problem of maintaining data, deemed to be one of the biggest problems of health entities. Most hospitals and clinic suffer loss of data saved in databases and unavailability of strong cohesive information systems.

The objective of this study is to design and implement a web-based EHR system that can help create a national repository of health data, and will therefore, make the deployment of telemedicine applications easier in the future. The EHR system ables to store the patient information, which normally includes personal information, address, demographics, progress notes, immunization, lab data, Radiology information, past medical history, family history, vital sign, tobacco history, alcohol history, examinations, and so on.

The proposed system consists of two another components, Queries system which is built to combine data from different tables by using a combination of mathematical or logical operators, Queries system used to answer on a an academic researchers questions. And the front-end of the EHR system which it is a set of GUI(Graphic User Interfaces) that act as a bridge in between the end users and the EHR system.

Keywords: Electronic Medical Record(EMR) , Electronic Care Record (ECR), Electronic Health Record (EHR), Computer-based Patient Record (CPR), and Electronic Patient Record (EPR).

1. Introduction

There are different names- acronyms for computer-based systems in healthcare, such as Electronic Health Record (EHR), Electronic Medical Record (EMR) , Electronic Care Record (ECR), Computer-based Patient Record (CPR), and Electronic Patient Record (EPR). These differences stem from the diverse arguments of the authors or refer to different levels in the functionality of the systems.

This research devote to EHR, which means the aggregate electronic record of health-related information of an individual. The record is created and gathered cumulatively across more than one health care organization and is managed and consulted by licensed clinicians and staff involved in the individual's health and care. The EHR is not a simple computer application; rather, it represents a carefully constructed set of systems that are highly integrated and require a significant investment of time, money, process change, and human factor reengineering [1, 2, 3].EHR where every patient's record and history from all the possible systems are consolidated in a pool. This information includes patient's demographics, progress notes, immunization, lab data, etc. Hence, it's a comprehensive view of patient's information.

An EHR enables the physician to see trends in the effectiveness of treatments, a nurse to report an adverse reaction, a researcher to analyse the efficacy of medications in patients with co-morbidities and so on. If each of these professionals works from a data repository, each will have an incomplete picture of the patient's condition. An EHR integrates data to serve different needs. The goal is to collect data once, then use it multiple times [4].

There are three key criteria for an EHR, integrate data from multiple sources, capture data at the point of care, and support caregiver decision making. As described in figure (1), this figure displays a conceptual model that depicts the technical system components that capture and integrate data and support caregiver decision making [5,6].

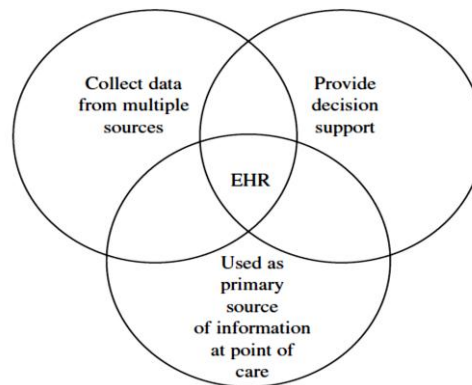


Figure (1): EHR criteria.

Furthermore, the EHR is not limited to a single location but, rather, should include remote access for providers and consumers; it should even be capable of integrating data across providers and from personal health records to form a longitudinal view of an individual's health status and healthcare.

The EHR has many advantages, it minimizes paper use, very efficient, portable, cost efficiency to its maximum, less prone to human errors, less chances of clinical data getting destroyed, security at any extent is possible, quickest reports for decision making, increases office revenues, and time saving at its maximum. [4, 7]

In another side, there are also several many challenges associated with EHR, for example, lack of good/affordable high-speed internet solutions and limitations in software, hardware and networking technologies, difficulty to adapt the new way of maintaining the office and data, it is an expensive task and needs a lot of finance.

This research was divided into several sections, section 2 describe the building stages of EHR model through the normalization processes , section 3 implementation of EHR components and their interconnections, section 4 describe the queries system and finally section 5 discuss some conclusions and future work suggestions.

2. EHR model building

After examining the business requirement and a clear understanding of the environment on which EHR will be build, we disintegrate the source EHR into several subject areas. The use of this is that it will make a clear partition with regards to different entities present in the healthcare industry and the way data will flow through these entities. Every subject area has its own importance and the data that corresponds to that subject area .Figure (2) Schematic presentation of the flow of information within EHR system. We will describe many Subject areas and the entities which interact with them.

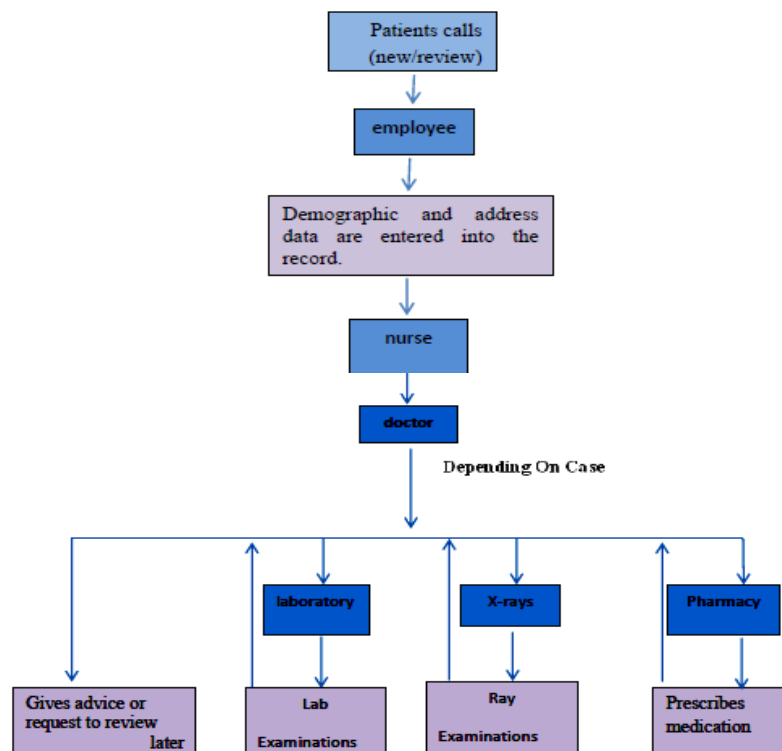


Figure (2) :The flow of information within EHR system.

In this section, we use the normalization forms, 1NF, 2NF, 3NF, 4NF, 5NF, and BCNF [7] to study the complex relations between data, to remove the redundancies, and to obtain to relational model for EHR system and EHR system schema. Figure (3) shows the proposal EHR Schema.

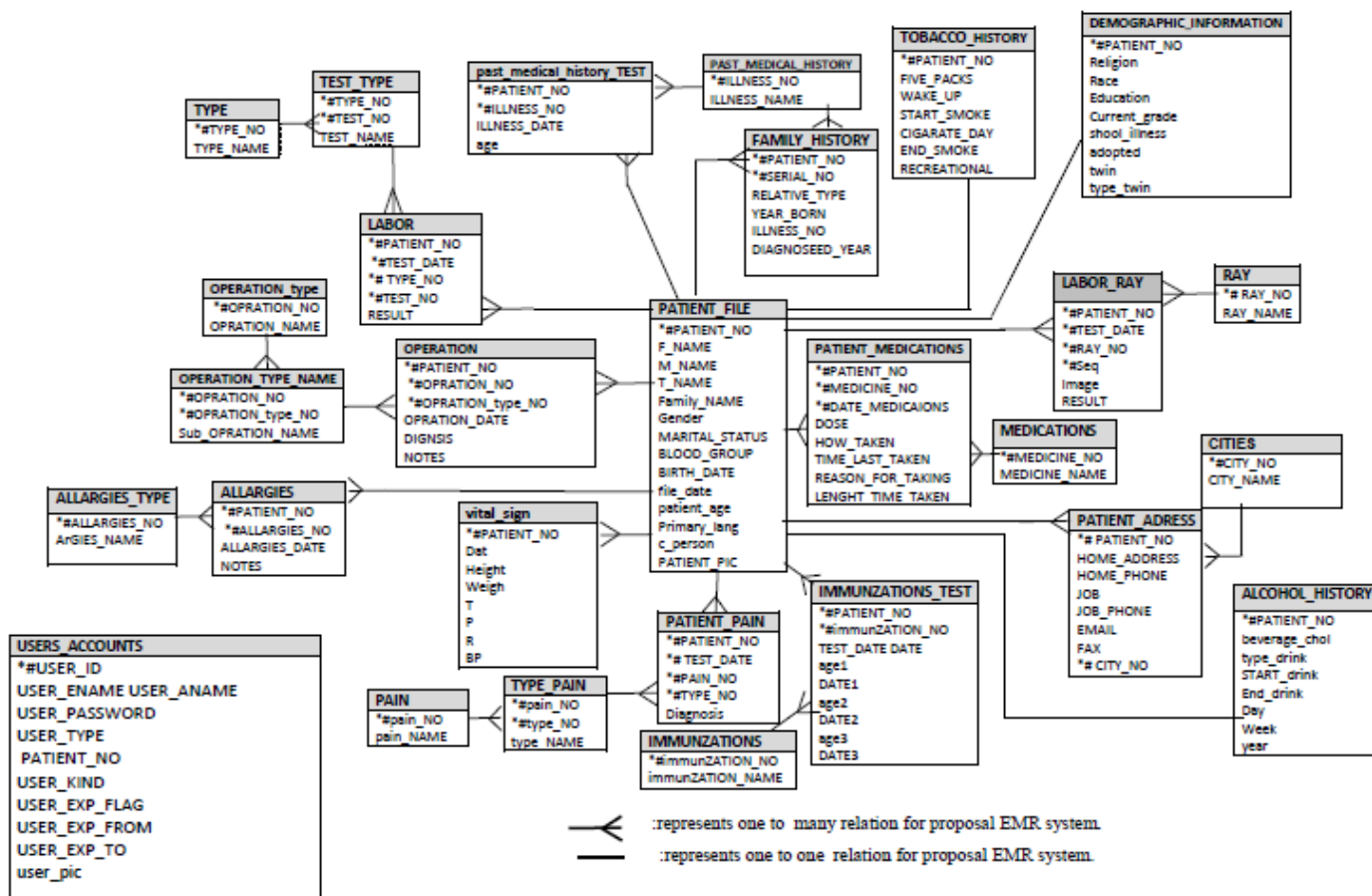


Figure (3): The proposal EHR schema.

The proposal of EHR schema was converted to corresponding relational Database using Oracle tools programming language.

3. EHR implementation

The objective of this research is to design and implement an EHR system. The core of this system is a database which is used to store the EHR information, which represents the back-end of the system; the front-end of the system is a set of GUI applications which act as a bridge in between the end users and the system. The implementation also, contain implementation the different queries , varying from simple query that is direct retrieval from corresponding table, to, complex queries according to complex conditions from different tables on database. And finally, last component of EHR system is interest to connect the EHR system to internet. The following subsections describe these parts in some details

3.1 Back-end (EHR-database)

Database plays role in storing of data, in this research, oracle database is chosen as the relational database management system to implement the EHR system. The data is stored in row and column style in the oracle relational database system. The collection of the rows and columns is

called table, and a group of tables constitutes database system. In the oracle relational database system, all the data are organized and linked by their relationship.

The proposed EHR system should be able to store huge amount of heterogeneous types data for different patients from different sources, The system should also support the following functions:

- Insert a new EHR manually
- Modify the items of the EHR manually
- Delete the EHR manually
- Search the patient by the category manually
- Also, offered services of data retrieval and display to specialist and academic students according to complex conditions they built at execution time.

The proposal EHR schema illustrated in section 2 defines the tables, fields, relationships between different data, and by using Oracle Tools , the EHR schema converted to appropriate relational database consist of different tables includes personal information, address, demographics, progress notes, immunization, laboratory data, radiology information Allergy, past medical history, family history, vital sign, tobacco history, alcohol history, examinations and son on, and, facilitatethere interconnections between them.

3.2 Front-end (user interfaces)

EHR system connect their data from different sources, this means, it must involve variety points from which the end user interacts, Users must do the login operation to enter the system. System will detect user 's name and password. And, It must have authorization and privilege system to different users. So that, the EHR system must have administrator to control all accesses and update operations of the system.

The EHR system divide their users into two groups : administrator (s) and General users.

Administrator : or the super-user, includes those people who are authorized to manage and manipulate EHR database freely , The administrator can do the following operations to EHR database: modify data, insert data, update data ,query data, and modify user's settings by giving an authorization and privilege to general user in EHR system through the privilege screen prepared to this purpose.

General User: points to all the people who will use this database system. It should include all the internal staff if the system is used for some local area and it should include all the internal and external staffs if the system is used in public. These users include , Physicians, Patients, Academic researchers, Employees, Chemists, X-ray operators, Laboratory operators, Nurses. For all these users, the GUI application and interfaces are developed and it provide some functions to enter data, display, search results, and allowed a simple and complex queries. The general diagramof EHR System illustrated in Figure (4)

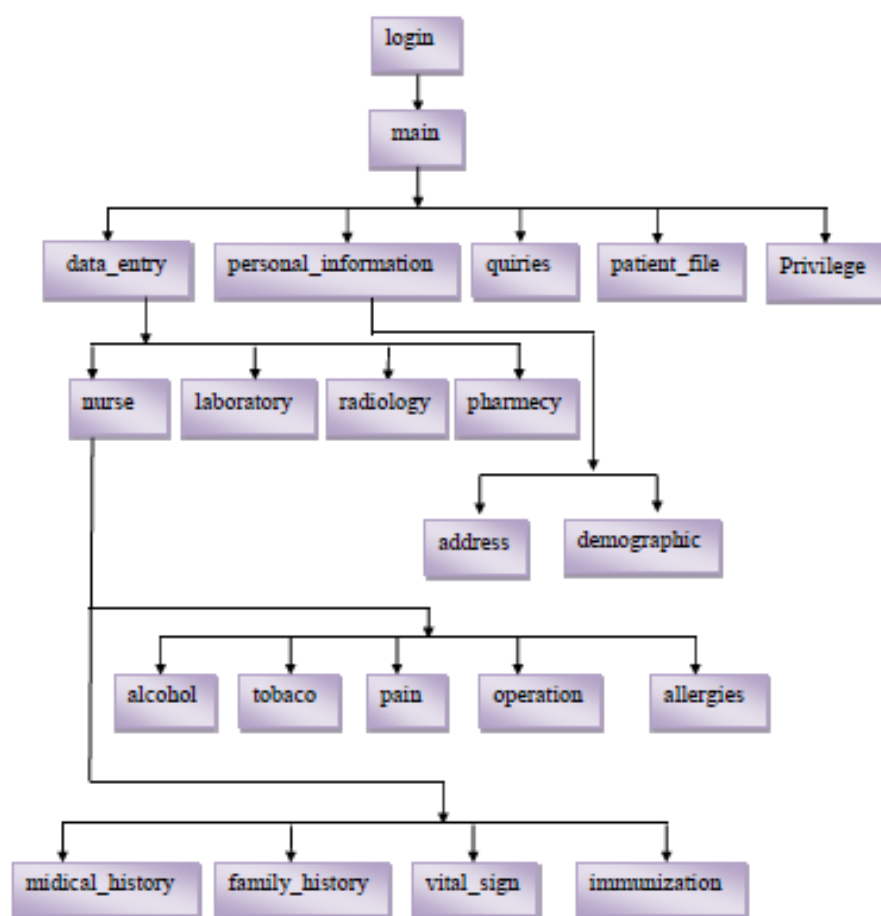


Figure (4): General diagram of EHR system interface

The above diagram illustrate the responsibility of each type of general user to enter, modify, display , and manipulation in general on certain types of patient data, for example, Nurse is authorized to do above operations on specific files like, alcohol history, tobacco history, vital signs , immunizations , allergies type, operations information , past history, family history. Laboratory is authorized to do operations labor tables. X-ray employee is authorized to do operations laborray tables. And chemist is authorized to do operations medications and patient medications tables. Figures (5) and (6) show some of these interfaces.

TOBACCO_HISTORY

Name

ali

esam

kazem

alwaely

A+

☐ MALE

☐ FEMALE

Birth Date

12/04/1960

Patient No

14

HAVE YOU SMOKED AT LEAST 100 CIGARETTES (5 PACKS) DURING YOUR LIFETIME?

☐ YES CURRENTLY SMOKE

☐ YES BUT QUIT SMOKING

☐ NO

HOW SOON AFTER WAKE UP, DO/DID YOU SMOKE YOUR FIRST CIGARETTE?

☐ 30 MINUTE OR LESS AFTER WAKING

☐ MORE THAN 30 MINUTES AFTER WAKING

ON AVERAGE, HOW MANY CIGARETTES SMOKE PER DAY?

20

HAVE YOU USED ANY RECREATIONAL DRUGS?

☐ YES, CURRENTLY

☐ YES, IN PAST

☐ NEVER

DATE WHEN YOU FIRST STARTED SMOKING CIGARETTES

15-JUN-2000

IF YOU HAVE QUIT, DATE WHERE YOU WHEN YOU QUIT?

ADD

QUERY

E_QUERY

C_QUERY

DELETE

EDIT

>>

<<

BACK

ALCOHOL_HISTORY

Name

☐ MALE

☐ FEMALE

Birth Date

O+

Patient No

DO YOU DRINK ALCOHOLIC BEVERAGES REGULARLY (AT LEAST 1 DRINK PER MONTH)?

☐ YES, CURRENTLY

☐ NEVER, RARELY

☐ YES, BUT QUIT

TYPE OF DRINK?

☐ PEER

☐ WINE

☐ LIQUOR

Start Drink

End Drink

NUMBER OF DRINK PER?

Day

Week

Year

ADD

QUERY

E_QUERY

C_QUERY

DELETE

EDIT

<<

>>

BACK

Figure (5): Nurse responsibility data.

RADIOLOGY INFORMATION

Patient No

58

Test Date

12/03/2013

RAY_NAME

Mephase

Result:

BACK

PREVIOUS

NEXT



Test Date	TYPE_NAME	TEST_NAME	Result
20/11/2004	URINALYSIS	Sp. Gravity	1.025
20/11/2012	STOOL ANALYSIS	Direct	yellow
20/11/2012	STOOL ANALYSIS	Cyst	histolytica
20/11/2012	STOOL ANALYSIS	R.B.Cs	5000
20/11/2012	STOOL ANALYSIS	Occult Blood	positive
20/11/2012	BLOOD ANALYSIS	WBC	6.4
20/11/2012	BLOOD ANALYSIS	RBC	3.29
20/11/2012	BLOOD ANALYSIS	Hgb	10.4
20/11/2012	BLOOD ANALYSIS	MCV	92.8
21/11/2012	Clinical Chemistry	Serum bilirubin	6
21/11/2012	Clinical Chemistry	Serum bilirubin(direct)	1
21/11/2012	Clinical Chemistry	Serum bilirubin	6
21/11/2012	Clinical Chemistry	S.AL(T(G.P.T)	6
21/11/2012	Clinical Chemistry	PH	7.4
21/11/2012	Clinical Chemistry	S.GLUPOSE	3.7

Figure (6): Radiology information and laboratory information

This responsibility to maintain different data by different users required developing an authorization and privilege system to prevent unauthorization access and modify data from any unauthorized user. The administrator only can manage and give users authorization by entering their information to EHR system and determine the user-name and password to anyone of them. Figure (7) show the screen to enter user authorization information.

USERS_ACCOUNTS

User Id

13

User Ename

ali

User Password

p1a*tt#%e&n@t

☐ DOCTOR

☐ DATA ENTRY

☐ ADMIN

☐ ACADIMIC RESEARCH

☐ PATIENT

Patient No

User Kind

☐ STATIC

☐ DYNAMIC

User Exp From

User Exp To

CLICK

ADD

QUERY

E_QUERY

C_QUERY

DELETE

EDIT

>>

<<

BACK



Figure (7): Privilege giving screen

3.3 queries system

The EHR system is a powerful and a huge source of information, it provides various cases and different information about patients to doctors ,academics and medical students. So, we devoted a special queries screen for these specialist users. By using dynamic pop list and complex conditions can be achieved with a great easiness and at insignificant time approximately. If an academic researcher has to view any patient's data, it will take few time for him to log in the system and search for it rather than asking the office staff to look for it from thousands of file bundles. There will be considerable increase in efficiency with the use of EHR by academic researcher in order to analyse and take decisions, and can make wise decisions by studying its data.

In concisely, this query screen introduces the following facilities :

- 1) A high interactive screen, this screen displays data from different EHR system files. Different color area represents or displays different patient files.
- 2) An Academic researcher can freely choose any field at run time.
- 3) The choosing process is depending on an easily way, it is used popup list , check box, or input any short string.
- 4) The query screen enables the academic researcher to build a simple query or a complex query from one file or from many different files at a run time by using the mathematical and logical operators.
- 5) This query screen is devoted to academic researcher who hopes to answer to his freely queries according to his research objective.
- 6) There are wide ranges of decision support queries which help to decide many factors while reviewing patient's details.
- 7) Effective patient's disease search which allows searching patients with similar symptoms/ disease and hence reviewing the possible medications for patient.
- 8) Another query screens are devoted to different system users, like nurse, employee, chemist, etc., which are compacted with data entry screens for each user type. These screens enables these users to execute different retrieval processes on their files, in purpose of making sure of entries correctness, and to perform appropriate data updates. also , these queries may be simple or complex queries. Figure (8) below show the query screen. And, figure (9) show the answer to query described below it.

The figure shows a screenshot of a query screen with the following sections:

- Top Section (Light Blue):** Fields for F Name, M Name, T Name, and Family Name, each followed by an 'AND' operator and a dropdown menu. Below these are fields for GENDER, Marital Status, and Blood Group, each with a dropdown menu. A 'SEARCH' button is on the right.
- Second Section (Pink):** Radio buttons for FEMALE and MALE, followed by an 'AND' operator and radio buttons for DIVORCE, MARRIED, WIDOWER, and SINGLE. Then, 'when Birth Date Between' followed by two date input fields and an 'AND' operator. A 'SEARCH' button is on the right.
- Third Section (Red):** Field for IMMUNIZATIONS_NAME, followed by 'when IMMUNIZATIONS Date Between' and two date input fields, an 'AND' operator, and a 'SEARCH' button.
- Fourth Section (Green):** Field for ALLERGIES_NAME, followed by 'when ALLERGIES Date Between' and two date input fields, an 'AND' operator, and a 'SEARCH' button.
- Fifth Section (Yellow):** Fields for RAY_NAME and RAY_NAME, each followed by an 'AND' operator and a dropdown menu. Then, 'when RAY Date Between' and two date input fields, an 'AND' operator, and a 'SEARCH' button.
- Sixth Section (Orange):** Fields for Type_name and Test_name, each followed by a dropdown menu. Then, 'When Lab Date Between' and two date input fields, an 'AND' operator, and a 'SEARCH' button.
- Seventh Section (Dark Green):** Field for MEDICATION_NAME, followed by 'when MEDICATIONS Date Between' and two date input fields, an 'AND' operator, and a 'SEARCH' button.

Figure (8): General query screen devoted to academic researchers.

Patient No	F Name	M Name	T Name	Family Name	Blood GROUP	Gender	MATIRAL STATUS	Lang uge	Birth Date	medcine Date
5	ناظم	غازي	عودة	النوسليمي	B+	MALE	MARRIED	ARABIC	14/09/1966	22/11/2000
10	علي	قاسم	حسين	الشايي	O-	MALE	SINGLE	ARABIC	14/09/1980	22/11/2000
15	ضياء	خيرى	عناد	اليومحمد	B+	MALE	SINGLE	ARABIC	04/02/1979	22/11/2000
20	ناصر	عبد الواحد	صالح	المسلمي	AB	MALE	SINGLE	ARABIC	04/02/1979	22/11/2000
25	ياسر	اسماعيل	ابراهيم	التميمي	B-	MALE	MARRIED	ARABIC	16/08/1966	22/11/2000
30	سجاد	حسين	علي	المساري	A+	MALE	SINGLE	ARABIC	16/08/1983	22/05/2005
35	ضياء	خيرى	عناد	النوسليمي	B-	MALE	DIVORCE	ARABIC	16/02/1970	22/05/2005
40	ناصر	عبد الوهاب	صالح	المالكى	AB	MALE	DIVORCE	ARABIC	16/02/1968	22/05/2005
45	اكرم	حاتم	عباس	الشايي	AB	MALE	WIDOWER	ARABIC	16/02/1978	22/05/2005
50	علي	ناصر	ثجيل	الكناني	O+	MALE	WIDOWER	ARABIC	16/02/1968	22/05/2005
55	شروق	طائب	علي	الحيدري	B-	FMALE	SINGLE	ARABIC	16/11/1980	22/05/2005
60	ريام	محمد	جواد	الشامي	A+	FMALE	SINGLE	ARABIC	16/11/1966	22/05/2005
65	زينب	احمد	سليمان	الموسوي	B-	FMALE	MARRIED	ARABIC	16/11/1975	22/05/2005
70	شهد	علي	صبري	المعتوق	B-	FMALE	MARRIED	ARABIC	16/11/1975	22/05/2005
75	زينة	غازي	محمد	المساري	B+	FMALE	SINGLE	ARABIC	16/11/1967	22/05/2000

Figure (9): The results of the associated example.

Query 1: List of all the patients are had illness name " Diabetes /Suger in Urine", medicine name " Buscopan" and medicine date between 03/05/1999 and 20/12/2006.

3.4 Connect to internet

EHR enable to access on a real time to any patient's record and its history from all the possible systems in any place in the world, because of, that all these information are consolidated in an integrated pool. This information includes a comprehensive view of patient's information. EHR also constitutes the collaboration of data from different entities like patients information, labs data for the patients and, other clinical data information related to the patient, hospitals, or from any medical institution in world.

in this case, the EHR system will ensure several advantages, such as, better accessibility, i.e., faster access to patient information, supports the security and integrity of the patient information, few or free from error, and many other.

4. Conclusions

The presented application attempts to reach solutions for some problems faced by leaders and decision makers and by those concerned with medical information systems. It assists health professionals in accessing patient medical information fast, creates a national repository of health data, and will therefore make the deployment of telemedicine applications easier in the future. In this manner, the presented system may improve the operation of the healthcare organizations. It makes quicker lab results, instead of relying upon traditional routines, many lab results can be returned to physicians as soon as they have been completed. This helps speed the entire process which reduces waiting periods. It provides an integrated system for managing and following up users of medical information systems.

The presented application has been a boon in health care segment and has helped in reducing paper to a great extent. It enables users of medical information systems to exchange data easily and fast. The presented application creates new opportunities for patients and physicians to interact in ways that were impractical only a few years ago. EHR provides admitting staff, physicians and

business professionals appropriate access to common patient data while maintaining privacy requirements. It also improves communication and collaboration, provide a great opportunity for early detection of epidemics and clinical audits, and enhance better resource allocation.

Finally, the EHR system is a huge project required participation and cooperation efforts of many foundations, hospitals, health centers, private clinical, and different specialists, in addition to governmental support and this work is a primary modest step toward a complete aim the EHR system.

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