Rochester Institute of Technology

RIT Digital Institutional Repository

2-1-2011

Electronic medical records concepts and data management

Shruti Sharma

Electronic Medical Records
Concepts and Data Management

Shruti Sharma

Submitted in partial fulfilment of the requirements for the degree of Master of Science

Department of Bioinformatics

College of Science

Rochester Institute of Technology

Rochester, NY

February, 2011

Approved: _____

Gary R. Skuse, Ph.D.
Thesis Advisor
Department Head, School of Biological and Medical Sciences
Professor of Biological Sciences

_____

Michael V. Osier, Ph.D.
Associate Professor
Director of Bioinformatics
School of Biological and Medical Sciences

<u>Committee Members</u>

Gary R. Skuse, Ph.D.
Thesis Advisor
Department Head, School of Biological and Medical Sciences
Professor of Biological Sciences
Rochester Institute of Technology

Michael V. Osier, Ph.D.
Associate Professor
Director of Bioinformatics
School of Biological and Medical Sciences
Rochester Institute of Technology

Anne Haake, Ph.D.
Professor
Department of Information Sciences & Technologies
Rochester Institute of Technology

Electronic Medical Records

Concepts and Data Management

By

Shruti Sharma

I, Shruti Sharma., hereby grant permission to the Wallace Memorial Library of the Rochester Institute of Technology to reproduce this document in whole or in part.

_____

Shruti Sharma

March 2, 2011

<u>ACKNOWLEDGEMENT</u>

There are many people that must be acknowledged for their technical and moral support that led to completion of this work. First I would like to thank my thesis advisor Dr. Gary Skuse for supporting me throughout and guiding me to explore my thesis topic. He provided vision, support, and encouragement and gave me the confidence to achieve my best.

Next I would like to thank Dr. Michael Osier for his dedication and helping approach towards me. I sincerely appreciate his suggestions given time to time, which polished the thesis and gave it a different dimension. He helped me with all the doubts I had regarding thesis and overall process.

A special thanks to Dr. Anne Haake for all her guidance and effort. Her suggestions and recommendations were truly beneficial and gave me a direction to develop better thesis.

Last but not the least; I would like to thank all my friends and family members for their emotional support, which is always the driving factor to achieve the best out of me. They are my source of inspiration and stand by my side at every step and guide me throughout.

ABSTRACT

Healthcare information (Clinical Data) is associated with every individual, young or old, rich or poor, belonging to any country. Clinical data is very extensive. Everyday some new diseases and new symptoms are being seen and the human race is struggling to find cures. There are many diseases whose diagnosis, symptoms, and possible treatment are known but unfortunately that rare knowledge is not available to every individual in the world. This initiates all the vision behind presenting a paper on EMR/ EHR and its Data Management.

The thesis reviews the concept of EMR/ EHR thus explaining its concepts, importance, market need etc. Thesis will also explain privacy and security related to clinical data in electronic format which is a very important as any electronic data is prone to hacks and data loss. To manage and utilize such amount of data, there is need of extensive data management and so the thesis explains the concepts of Datawarehouse, its importance, ETL, Schemas etc. As part of explaining these concepts a mini EMR/EHR Datawarehouse is designed which explains various subject areas possible in any EMR Datawarehouse. Last but not the least, the thesis comments on the Future of EMR/ EHR and the World Vision on this revolutionary change.

Table of Contents

1   Introduction

Let us examine a scenario that is repeated far too often. Our friend Bingo is ill and needs to get a checkup done. He steps into a physician's clinic and this becomes his first encounter. He fills in his Demographic information - his basic information like Name, Address, Insurance Details, Symptoms, and Allergies etc. All this information is physically put into a paper chart, clipped and sent to the doctor for review. The doctor treats Bingo and asks him to perform a few tests and asks to see him again in few days. The doctor now clips his own notes to Bingo's chart along with notes on the tests he recommends, symptoms; diagnosis etc. From here on Bingo's file is in the process of settling into the physician's office for a very long time. Every time any information about Bingo is received, it's stored in that file making it "Healthy".

What results after a few short years is a common scenario in offices that do not manage records electronically; floor-to-ceiling paper stacks containing important data, misplaced files, lost files and time consuming searches. The paper stacks become too large at one point to become practical, most sites end up hiring additional staff just to manage these paper stacks.
[Fig.1 – EMR Story]

EMR (Electronic Medical Record)/ EHR (Electronic Health Record) provide an effective way to solve the problem of managing clinical data. EMR has in fact been playing a minor role in the industry for many years but has yet to be implemented successfully end-to-end because of the many hurdles it has faced such as privacy concerns, cost and simply the lack of technology. In recent years a lot of progress has been made in terms of legislation, technology and innovation in information technology all of which has helped clear out some of these hurdles. With recent advances in IT; intelligent software, advanced processors, high-speed networks and seemingly limitless storage capacities have all revolutionized the industry. Add to that excellent data processing tools and we have a whole different dimension on how we extract and use meaningful data. [Fig. 2 – Clinical Charts]

It is very crucial to understand every little pixel of the portrait; this thesis will try to touch as many parts as possible with details that makes the EHR/EMR healthcare effort successful. The thesis takes a close look at the advantages, disadvantages and hurdles of EMR/EHR as well as explains the overall working of EMR/EHR with respect to government standards of privacy and security. The thesis will also look at a few of the EMR/ EHR market players and the different services they offer. The next part of the thesis will explore Datawarehousing concepts which are an important topic in the technology behind EMR/EHR. Datawarehousing plays a very significant role in storing, maintaining and using the enormous volumes of data involved. As part of explaining these concepts a mini EMR/EHR Datawarehouse is designed and the concepts of E.T.L (Extraction Transformation Loading) schemas and clinical data mining subject areas are explored. The latter part of the thesis will look at EMR/EHR Benefits & Challenges and will try to speculate the future of EMR/EHR.

1.1   What is Electronic Medical Records (EMR)?

Electronic Medical Recording – All the data in a doctor's office is usually collected in the form of charts and forms on papers. Using the paper record creates piles of papers and it is difficult to manage and utilize these records.

Electronic Medical Record is the term given to medical record of patients collected in electronic format.

Electronic records are easily portable and accessible anytime and from anywhere. It is easy to transfer electronic records to several different entities at a time. With the extensive growth in technology it is now possible to maintain the data in electronic format and this electronic data can be utilized for analysis of business, patient care, and physician performance and for various other researches.

EMR/ EHR is a step towards a world of healthcare where all the processes related to clinical data will be automated and well structured. This will help patients to get better health care, physicians to get timely information and thus improving the overall medical system. Due to its many advantages, EMR is the new wave of this generation and is getting the most attention in the world. [1 - 4] Fig 3 is small workflow diagram which describes the concept of EMR.
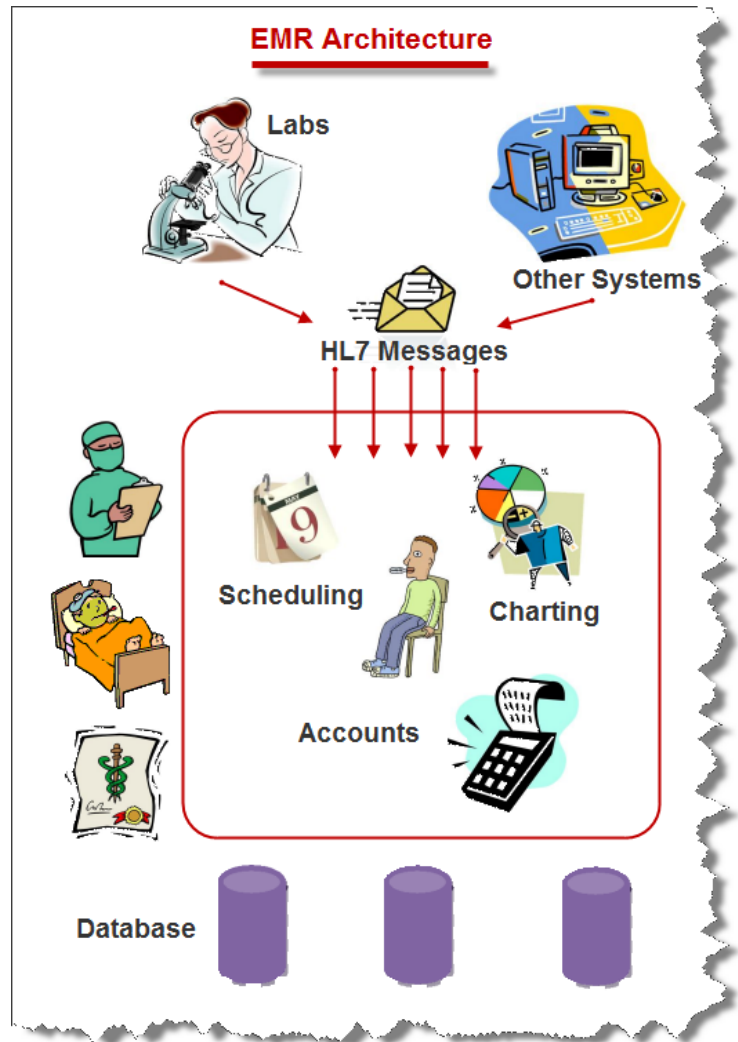
[Fig. 3 – EMR Architecture]

Some important terms that are associated with the healthcare domain which an EMR/EHR system should have are privacy and security of the patient's sensitive information. HIPAA rules comes into picture which deals with privacy and security of electronic healthcare data.

One of the main reasons the world is moving towards EMR and documenting everything digitally is to have a unified information pool. This pool will carry every bit of information related to the health care. Interoperability is one of the major hurdles in forming this pool and automating the process of healthcare. But with advancements in technology and understanding of standards, this is very much reachable although difficult. [5 - 7]

"A patient record system is a type of clinical information system, which is dedicated to collecting, storing, manipulating, and making available clinical information important to the delivery of patient care. The central focus of such systems is clinical data and not financial or billing information. Such systems may be limited in their scope to a single area of clinical information (e.g., dedicated to laboratory data), or they may be comprehensive and cover virtually every facet of clinical information pertinent to patient care (e.g., computer-based patient record systems)." [8]

EMR – EPR – EHR

Electronic Medical Record is a term that is mostly used in US Healthcare. But in UK healthcare, Electronic Patient Record is widely used. EMR and EPR are interchangeable. NHS (National Health Service) has given a definition of EPR for the UK healthcare which is:

"An electronic record of periodic health care of a single individual, provided mainly by one institution".
This makes it more patient specific. [9]

Often Electronic Medical Records and Electronic Health Records are used in the same way. But there is a difference between Electronic Medical Records and Electronic Health Records. NAHIT – National Alliance for Health Information Technology has described the basic difference in EMR and EHR.

"EMR: The electronic record of health-related information of an individual that is created, gathered, managed, and consulted by licensed clinicians and staff from a single organization who are involved in the individual's health and care.

EHR: The aggregate electronic record of health-related information of an individual that 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." [10]

To make it simple, EHR is a bigger umbrella and EMR is a part of it. If we look at the bigger picture of American Healthcare then we are talking about EHR where every patient's record and its history from all the possible systems are consolidated in a pool. This information includes patient's demographics, progress notes, immunization, lab

data, reports etc. Hence it's a comprehensive view of patient's information. EMR 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. But in case of EMR this data has boundaries that are limited to a single practitioner or single hospital facility. It will be a drastic improvement in diagnosis of any disease and retrieval of patient's record across the globe. EHR will help in many departments of healthcare. [11]

Hence it can be concluded that an EMR with interoperability can be considered as an EHR. EHR will provide a wider angle to the patient's information as it's getting its data from many other systems where patient's information is stored hence providing clinical decisions and to analyze health related maintenance requirements. This helps the physicians to measure the quality standards and reports in order to get the pay for performance incentives. But in the market EMR is the term which is used in a more popular way. Even most of the Clinical Record Systems companies market their products as EMR product. But to use EMR or EHR, depends on the facilities requirement. [12, 13]
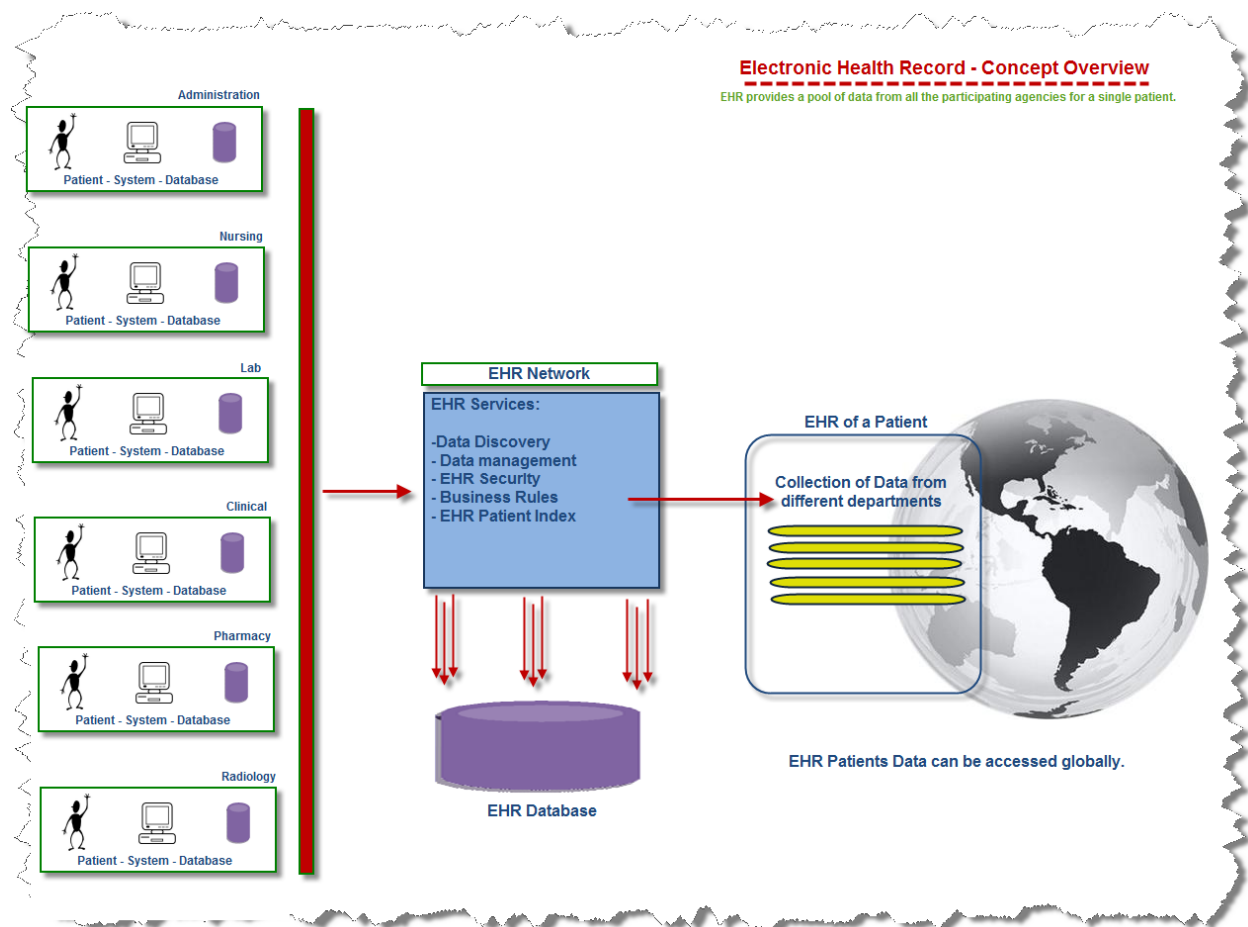
[Fig. 4] – Electronic Health Record - Overview

EMR	EHR
• **It's the record and responsibility of the care delivery organization. For example if a patient visits a Physician clinic then that physicians EMR system will be the one responsible for its records and it will be property of that Physicians Clinic.** • **The patient can access the information but cannot change it.** • **Patients encounter information is present in the facility.** • **It does not contain any information from other facility. [14-16]**	• **The record is owned by either the patient or the stakeholder.** • **This is interactive and gives the ability to the patient to change its information very easily.** • **Patients encounter information from all the facilities are being combined and are present in a pool.** • **EHR is connected to National Health Information Record (NHIN)** • **To achieve EHR, EMR should be active in any facility. EMR is the first step to achieve EHR.**

EMR Adoption – Path to EHR

Considering the US Healthcare challenges and the awareness of EMR in healthcare industry, Healthcare Information Management Systems and Society (HIMSS) has come out with a seven stage model and have studied different hospitals at every stage. They have considered about 4000 US hospitals present in their database to come out with this analysis.

The statistics of this model states that:

• Around 11% of the hospitals are at stage 0 which means that the key ancillary departments like laboratory, radiology or pharmacy are not installed in these hospitals.

• About 6.8% of hospitals are at stage 1 which means that the key ancillaries are installed in the hospitals.

• Around 16% of the hospitals are at stage 2 which means major systems store and access the data from their clinical data repository. The hospital is at HIE (Health Information Exchange) stage where it can share its information with other patient care stakeholders.

• Around 50% hospitals are at stage 3. Meaning that documents like vital signs and flow sheets are at place. The first level of clinical decision support is at place to conduct error checking. Some level of Medical Image access from PACS (Picture Archive and Communication System) is available for the access to the physicians outside the radiology department.

• Around 7.7%-9.7% hospitals are at stage 4 which mean that CPOE (Computerized Practitioner Order Entry) is added to the nursing and error checking related to evidence based medical records is at place.

• Around 4% hospitals are at stage 5 which means the closed loop medication administration environment is fully at its place. The Electronic Medication Administration Record (eMAR) and bar coding or other auto identification technology, such as radio frequency identification (RFID), are implemented and integrated

with CPOE (Computerized Practitioner Order Entry) and pharmacy to maximize point of care patient safety processes for medication administration.

- Around 2% of hospitals are at stage 6 which means that full physician documentations or chartings like structures templates are implemented. PACS system provides medical images to physicians by internet and displaces all film based images.

- Around 0.7% of hospitals are at stage 7 which means the full hospital is now electronic based. It no longer uses paper charts. Clinical data warehouses are being used to analyze patterns of clinical data to improve quality of care and patient safety. Clinical information can be readily shared via standardized electronic transactions (i.e. CCD) with all entities that are authorized to treat the patient or a health information exchange (i.e., other employers, non-associated hospitals, sub-acute environments, ambulatory clinics, patients & payers in a data sharing environment). The hospital demonstrates summary data continuity for all hospital services (e.g. inpatient, outpatient, ED, and with any owned or managed ambulatory clinics). [17]

Below is the analysis provided from HIMSS, for US EMR Adoption.

Stage	Cumulative Capabilities	Quarter 1 – 2010	Quarter 2 - 2010
7	Complete Installed EMR, CCD transactions to share the data, Data Warehousing Concepts developed.	0.7%	**0.8%**
6	Full physician documentations or chartings like structures templates are implemented. PACS system implemented.	1.8%	**2.6%**
5	closed loop medication administration environment is fully at its place, eMAR, RFID implemented and integrated with CPOE	5.0%	**3.2%**
4	CPOE is added to Nursing and Error Checking implemented	7.7%	**9.7%**
3	Nursing and clinical documentation implemented. Some level of PACS	50%	**50.2%**
2	Major ancillary systems feed data into their clinical data repository	16.5%	**15.5%**
1	Key ancillaries are installed in the hospitals.	6.9%	**6.8%**
0	Key ancillaries are not installed in the hospitals.	11.4%	11.2%

[17, 18]

1.2   Clinical Data in Paper Format – A Big Problem!

"In the U.S.A., 14% of U.S. Gross Domestic Product (GDP) was spent on healthcare in 2001 (U.S. OECD) or $1.5 trillion (U.S. HCFA). $250B was spent on healthcare-related communications services, administrative and transaction services.   According to a 2001 Arthur D. Little study $100B of the $250B was directly attributable to inefficient communications. 25% to 40% of the $250B represents excessive administrative and paperwork overhead."

There are a several reasons that make us think in a direction to develop a system which can overcome the problems laid by the use of clinical data in hard format. Some of the problems are as follows: [19 - 24]

Paper, Paper and Paper:

It involves a lot of paper to maintain any type of records. And when it comes to medical records then it is limitless. There is so much information which is linked to a patient that to maintain it, needs a great organized structure of piles of files. Maintaining records in paper format is cumbersome and as the records grow, it takes a leap towards inconsistency and is difficult to maintain. With this, paper also has few limitations like it grows old and there is always a chance that it gets spoiled either by water, fire or bugs etc. [Fig. 5 – Paper Pile]

Manpower and Efficiency:

To maintain the piles of paper records, manpower and time is required. Data in paper format also slows the work as compared to the rapid retrieval of information by the use of electronic data. Search for the relevant record or to retrieve useful data may require a lot of time and man powert. There is a lot of staff needed and there is a huge risk of error involved in retrieval of data manually. [Fig. 6 - Balance]

Non Portability:

Looking at the global world and the way its getting squeezed its really crucial for a doctor to be in touch of his records from anywhere in the world. The physician can do his work from anywhere and can refer to any patient's diagnosis which in turn is very helpful in dealing with other patients. With the use of paper records this cannot be attained and when the doctor is away from office, he is AWAY FROM WORK. What best the physician can do is to call his staff from remote location and ask for the details but this involves lot of data errors and might not be so secure and is a privacy and security threat to the data. [Fig. 7 - Coins]

Cost inefficiency:

Storing and maintaining the patient's record in paper format requires many resources and hence increases the cost. But retrieving the paper files becomes impossible when there are thousands of files in an office. And so the cost to store and maintain records in underutilized. On the other hand when electronic data is stored it's easy to retrieve and can be utilized again and again. Thus giving maximum return of investment. [Fig. 8 - Bank]

Human Errors:

The records maintained manually on papers are prone to lot of human errors which is one big problem. Managing the current records and history of patients is very big task. There can be loss of papers and records in the process of managing files. The amount of errors can reduce if the data is stored in electronic format.[Fig. 9 - Error]

Coordination:

There are many different entities involved in a patient's record and this is getting increased day by day. A patient may visit any doctor's office and can get his blood test done from a pathology lab, gets his X Ray, CT Scan etc done at other radiology lab. In order to get these test results the patient or the lab has to communicate and send the reports to doctor's office by mail which is a big problem of coordination. It also delays the whole process and may result in errors and security breach for the data. [Fig. 10 – Office Coordination]

Inter Office Communication:

A patient can visit many departments once he/she enters a hospital. It can take hours for a file to reach from one department to other, slowing the overall process. If the data is updated and stored electronically, it is available immediately to every department who has the access to the system. Thus there is no delay in communication between the departments. [Fig. 11 - Communication]

Decision Making:

With data in paper format any kind of analysis is difficult. On the other hand if organization's data is collected in electronic format, a lot of analysis is possible. The patient's record can be used to see how a medicine in reacting on group of patients, physician's performance can be evaluated; a lot of other business analysis over the time can

also help in improving the organization and health care.

Dependency:

The patient's record in a physician office are filed and stored by the clerical staff. When these records need to be retrieved, there is always dependency on the staff. The pile of files makes it difficult for a physician to look for record themselves. On the other hand when the records are in electronic format it is much easy to look for a patient's record. It can be searched by name or social security number or date of birth. [Fig. 13 - Dependency]

Security:

Keeping clinical data on papers is not so secure. It can be stolen by anyone who has the access to the place where papers are kept. The security issue comes into picture when the data travels between different entities like labs, physician's office, insurance providers etc [Fig. 14 – Security]

2   Comparison

An article from Health Management Technology (4/2002) shows EMR system saves time when it is used vs. manual methods at California Pacific Medical Center (CPMC) in San Francisco, CA.

Few figures below give an idea to compare EMR vs. Manual Methods.

Category	Manual	With EMR
Complex NICU patient Discharge Summary	120-180 Min	**30-45 Min**
Complex NICU patient Daily Progress Notes	30-60 Min	**20-40 Min**
Chart Coding of Uncomplicated Deliveries	**5 Min/ Chart**	**1 Min/ Chart**

[25]

Paper Office – Without EMR	Paperless Office – With EMR
1. Lot of Paper Use	1. Minimal Paper Use
2. Lot of Manpower Use	2. Minimal Manpower Use
3. Not so Efficient	3. Very Efficient
4. Not Portable	4. Portable
5. Cost Inefficient	5. Cost Efficiency to its Maximum
6. Prone to lot of Human Errors	6. Less prone to Human Errors
7. Clinical Data might get destroyed	7. Less chances of Clinical Data getting destroyed
8. Not so secure	8. Security at any extent is possible
9. Decision Making is not so quick	9. Quickest reports for Decision Making
10. Lot of dependency on staff	10. Less dependency on staff
11. Same office revenues	11. Increases office revenues
12. Less time effectiveness	12. Time saving at its maximum
13. Data collection from different office is not so effective	13. Automated data retrieval from different offices
14. The data in paper format is difficult to organize and retrieve.	14. Electronic data is very easy to organize and retrieve.

[25 - 33]

3   Privacy and Security

One of the major concerns that is restricting the fast development and use of EMR in the nation is the concern for privacy and security of sensitive patient's data. No matter how secure a system is, it is prone to hacking. May it be a highly secure bank system or a single system implemented at a physician's office, wherever the information gets online and runs through the web pool, it's prone to attacks. [34]

For example in year 2006 a laptop got stolen from the residence of a staff person of the U.S. Department of Veterans Affairs. This laptop contained around 26 million of Veteran Administrative records. This is not the only event of security breach. There are many more such incidences where sensitive information got lost. Some familiar organizations where similar kind of incidences happened includes Aetna, HP, Fidelity Investments, Equifax, Federal Trade Commission etc. [35]

Today, the technology has evolved to a great level and the systems are made very secure. Different level of authorizations makes it shelled and intact. There are many different companies which provide intelligent products to minimize the data loss. These vendors design the system in a way so as to introduce high end authorizations and security frameworks on top of the data and thus it becomes difficult for hackers to breach the system. [36]

The strong privacy rules make EMR adoption difficult in various hospitals and institutions. There was research done by Massachusetts Institute of Technology and University of Virginia researchers. They found that the states where the privacy rule is stringent has less EMR adoption as compared to states with a little privacy rules. The states with high privacy rules make it difficult for the hospitals to share the information as it's expensive and troublesome. Also the hospital or any facility needs to follow a number of standards defined by HIPAA and etc which are difficult to implement and maintain. [37]

The privacy rules are being formed by HIPAA and they decide how medical information should be shared between different systems. The rules are good if the patient wants the access to the records but the problem arises when any other organization needs access to patient's records for any research purposes. The HIPAA laws implementation is a confusing and complicated task and to implement these rules is yet an extensive task for physicians or healthcare providers. [38]

Patient's health records have yet another dimension to privacy. The companies who offer free web space where patient can upload the data do not guarantee that the data is safe. Other companies who claim to keep the patients data private asks for other rights like data mining.

The privacy and security is implemented at many levels in securing electronic data. The levels cover a broad range from overall rules to deep down to the data level.

Title II of HIPAA deals with Preventing Healthcare Fraud and Abuse. It defines many rules and offences for sensitive data loss at every possible level. There are many programs which are defined in HIPAA to guard the privacy of data like

i. Fraud and Abuse control program [39]
ii. Medicare Integrity Program. [40]

There are mainly five rules which HHS (Health and Human Services) has formulated which are the privacy rule, the security rule, the transaction and code set rules, unique ID rule and enforcement rules. [41-43]
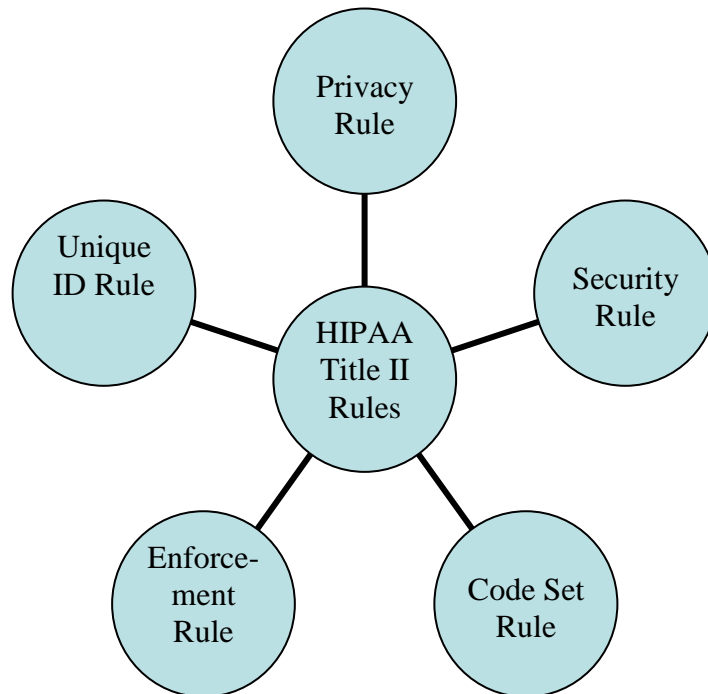
[Fig. 16] –HIPAA Title II Rules

3.1   HIPAA Privacy

The first level to implement privacy of clinical records is to define rules which guides how the records can be accessed or transferred. At different levels the privacy is implemented as follows:

Privacy Implemented by HIPAA Rules:

The privacy rule established on April 14' 2003 for HIPAA by HHS (Health and Human Services) is also called Standards for Privacy of Individually Identifiable Health Information. This rule mainly deals with the use of individual's health information called "Protected Health Information". The main aim of Privacy Rule is to guard the patient's sensitive information during the flow of information from one entity to other. This rule is very flexible so as to cover various uses and revelations which need to be addressed. [44]

As Per the Title II of HIPAA, *Department of Health and Human Services (HHS)* has defined standards for use of clinical data in electronic format. The entities that have to follow the HIPPA privacy rules are called "Covered Entities". The covered entity includes:

- Health Plans
- Health care providers who transmit clinical data,
- Community health information systems and organizations which deal with billing services.

The Office of Civil Rights - OCR is responsible for Privacy Rule with respect to Voluntary Compliance Activities and Civil Money Penalties. [45]

 Privacy rule is not mandatory for all organizations. Examples of organization which are not covered entities are :

- Life insurance companies
- Law enforcement agencies
- Employers
- Workers compensation carriers
- Schools and their districts
- State agencies
- Many municipal offices.

The covered entities may also take service of other agencies or individuals which are called as "Business Associates" and who provide services on behalf of or to the covered entities and whose services involves

transmission of patients health information (PHI). Few of the services performed by business associates are like claims processing, data analysis, billing etc. [46 – 47]

Covered Entities

Health Care Provider

- **Doctors**
- **Clinics**
- **Psychologists**
- **Dentists**
- **Chiropractor**
- **Nursing Homes**
- **Pharmacies**

Health Plan

- **Health Insurance Companies**
- **HMO's**
- **Company Health Plans**
- **Gov Programs (Medicare, Medicaid)**

Health Care Clearinghouse

Includes public or private entities which get non standard health information from other entities into standard electronic format or vice versa. Example: Billing Services, Repricing Companies, Community Health Information system etc.

[Fig. 17] - Covered Entities

Health Care Provider

A provider who transmits clinical data electronically comes under the category of Covered Entities and is bound by the Privacy Rule. These transactions can be

- Claims
- Enquiries for Benefit Eligibility
- Referral Authorizations requests
- Any other transmission which has been identified by HHS and has formulated standards under the HIPAA - Transactions Rule.

Health Plan

Plans which come under health plan are the ones which provide or pay the cost of Medical Care. Few of the plans are:

- Health Plans
- Dental Plans
- Vision Plans
- Insurers like Prescription Drug Insurers, Medical Supplement Insurer (with exception where insurance entities which provide only workers compensation, and other types of insurance like automobile, property etc)
- HMO's (Health Maintenance Organizations)
- Medicare & Medicaid
- Employer Sponsored group health plans (with an exception if the health plan has less than 50 members and the employer establishes and maintains the plan)
- Church Sponsored Health Plans
- Multi Employer Health Plans
- Government sponsored Health Plans (exception are programs like food stamps program and health plans servicing community health center)

Health Care Clearinghouse

These include public or private entities that get non standard health information from other entities into standard electronic format or vice versa. Few types of clearinghouses are like:

- Billing Services
- Reprising Companies
- Community Health Management Information Systems

The Protected Health Information (PHI) includes sensitive patient's information related to physical and mental health information, patients past and future information and payment for any medical situation. It also includes the health care provision provided to individual. This information is called as "Individually Identifiable Health Information" which includes Patients Name, Address, SSN, DOB etc. The privacy rule suggests that the PHI is disclosed by covered entities only if the privacy rule permits or an individual wants that information or if the individual authorizes someone to get information on its behalf. This information can also be shared with HHS when it is responsible for review or enforcement action or an investigation. [46 – 47]

Disclosure of information is a very crucial step in deciding the privacy rule. There are many situations where a covered entity may disclose PHI but it has tight boundaries.

The covered entity can disclose information in following situations or to following entities:

Individual	Patient itself.
Treatment	Health Care Provider and related services activity.
Payment	Disclose of information related to health plans which involves payment of the treatment used on the patient.
Health Care Operations	In the case of improvement activities by health care organizations, activities related to competency of health care or provider performance, for reviews, legal activities and audits, business management or administrative activity of covered entities. Also the disclosure of psychotherapy notes for disclosure of payments, treatment and health care operation requires patient consent to disclose PHI.
Directory in a Facility	In the case of hospitals patients are asked to give an informed consent wherein patients name, their medical condition, and location in the facility is being disclosed. This is important so that if anyone wants to locate the patient they can do so by the patient's name.
Family members or authorized persons	The covered entity may want to disclose PHI to family members of the patient. This might be in the case of emergency etc. The PHI may be disclosed to entities authorized by the law for any disaster relief.
Public Interest and Benefit Activities	There are 12 such cases which adhere to National Interest and in these cases the PHI can be distributed without any consent from the patient. These conditions are as follows : • Information required by law e.g. By court order. • The person has committed some crime or has broken any law then PHI can be shared to respective government agencies. • Health Oversight Agencies may get the PHI for their legal activities. • For any Judicial or Administrative Proceedings. • For law enforcement purposes. • To the agencies for identifying the death of a person or to the funeral directors. • To facilitate the donation of organs of the dead. • For any research activities.

	• Threat to health and safety of any community or nation. • To run important Government functions. • For workers compensation related to workers illness or injury or death.
Limited Information	Belongs to the information from unique identifiers related to the patient or its relative is being removed. This information can be used for general research purpose, public health responses etc.

Another important dimension to Privacy Rule is the concept of "**Minimum Necessary**" disclosure of PHI. It's the duty of covered entities to try to its maximum to disclose only that information which is necessary. Also inside the facility of the covered entity, it should try to shield as much information as possible from its other staff and should develop system which will work on different roles. Covered entities should also implement some rules which will target the routine disclosure of records and to implement the concept of minimum necessary on those routine disclosures. Also the covered entities should provide notes which describe the roles and duties on the entity and also the measures it takes to protect the PHI. [46 – 47]

For a covered entity to run its processes, it needs to implement and define a few procedures and practices like:

1. Procedures and Policies for Privacy
2. Appointing of a Privacy Person who is responsible for developing these rules and procedures. [48]
3. The privacy rule also governs the covered entities to make sure they appoint some person whom the individual can contact and also keep track of the information of the patient disclosed.
4. Training for the covered entity workforce to understand the privacy rule.
5. Mitigation should be done by covered entity for any effects it has learned from leaking of PHI from its facility.
6. Security of data at every level like software level, physical level etc.
7. Data backup of 6 years of PHI.

Actions against breach of Privacy Rule

Covered entities not following the privacy rule are subjected to fines and criminal prosecution. These penalties are and should be very aggressive so that the sensitivity of the information and data should be understood by the covered entities. Bottom line is - Nothing should be taken lightly when it comes to PHI. These penalties are being imposed by OCR (Office of Civil Rights).

This penalty is being divided into two groups:

A. Violations occurring before 2/18/2009:

Penalty Amount: up to and 100/ Violation and up to $25,000/ Calendar year

B. Violations occurring after 2/18/2009:

Penalty Amount: $100 to $50,000 or more/ Violation and up to 1.5 Million/ Calendar year

If the error is corrected within 30 days and was not a willful neglect then the OCR might withdraw the penalty. One more scenario where OCR might not take action is when Department of Justice has imposed a Criminal Penalty on the covered entity. Criminal Penalties are imposed if the person has knowingly distributed/disclosed the PHI. It might result in High Penalties and imprisonment. [48]

Privacy Implemented at Software Program level:

The privacy rule defines the data safeguards policies to maintain the privacy of the data by the covered entities, but when it comes to the software level there is a lot to be considered. The covered entity needs to purchase software from a trusted vendor which will be used to handle the patient's data and regular processing under the covered entities facility.

Use of licensed software for EMR and for other data processing and transfer is mandatory to maintain software level privacy. The licensed software should have features to encrypt the data so that it is secure.

If required, some privacy software should be used in physician's office or hospital. The use of this privacy software is to keep watch on the user's activities and they also create a type of firewall when it comes to sharing of secured data. Only filtered data that is configured by the administrator can be transmitted over the internet and out of the network.

There are few software products which can hide the users IP address. It is very important so that any hacking robots don't steal the IP address and try to get into the users system. If any user machine contains sensitive patient's data then it's very important that the data is shielded from internet access. Hence use of any privacy software is recommended. Some of the privacy software's available in market are as follows: GNU Privacy Guard, Secure Shell etc. [49]

3.2   HIPAA Security

Security is implemented at many levels of access.

Security Implemented by HIPAA Rule:

The latest security rule is established in Feb 20, 2003 and it specifically deals with Electronic Protected Health Information (EPHI). It is basically a subset of the Privacy Rule. All of these rules states security standards and for these standards there are required and addressable implementation specifications. The required ones must be adopted and utilized. On the other hand the addressable specifications are much more flexible and the covered entity can figure out which one is best for it. [50 – 51]

To compliment the HIPAA Security Rule the covered entities should do the following:

- Maintain the integrity & confidentiality of Electronic Patients Health Information - ePHI whether it's been created, received, maintained or reviewed.
- Covered Entities should protect against any hazards which might be a risk to privacy and confidentiality of the ePHI.
- Covered Entities should protect against any uses which might cost the privacy of the information.
- Covered Entities should ensure that the workforce is complying with the standards.

The security series of papers has published seven papers and each of them deals with a particular aspect of the rule. The details are provided under section 164.308.These are as follows: [50 – 55]

1.   Security 101 for Covered Entities
2.   Security Standards – Administrative Safeguards
3.   Security Standards – Physical Safeguards
4.   Security Standards – Technical Safeguards
5.   Security Standards – Organization Policies and Procedures and Documentation Requirements
6.   Basics of Risk Analysis and Risk Management
7.   Implementation for the small provider.

Let's describe each one in detail:

Security 101 for Covered Entities

Administrative simplification rules are being described in it which contains Privacy Rule, Electronic Transactions and Code Set Rules, National identifiers Requirements for Employers, Providers and Health Plans and Security Rule. This Rule also describes the difference between the Privacy and Security Rule. [53]

Privacy Rule	Security Rule
This rule defines who will have the access to the PHI	This rule ensures that those who have access to PHI, have the access
This is applied to all forms of patients data like Electronic Data, Oral Data, Written Data	This is confined to information stored electronically i.e. EPHI that is maintained, created, received or transmitted.

Security Standards – Administrative Safeguards

These are policies and procedures that are developed to manage the way the security standards are being implemented on EPHI. [53]

List of Standards under Administrative Safeguards are as follows:

Administrative Safeguards	Explanation
Security Management Process	This requires the covered entities to implement policies and procedures which will prevent, detect correct and contain the security violations.
Assigned Security Responsibility	This means assigning a security official responsible for the implementation & development of policies and procedures related to the covered entities.
Workforce Security	This means implementation of policies and procedures for the workforce members of a covered entity which will state that the members will have access to limited patient's information. So by this rule it will be decided that which person has access to which information.
Information Access Management	This means the access of the information to only the restricted persons.
Security Awareness and Training	This means that the covered entities should organize security training sessions and programs for all the workforce members so that they will get to know the sensitivity of PHI and can act accordingly.
Security Incident Procedures	These are the policies and procedures to address the security incidents.
Contingency Plan	If there is any emergency then what are the steps involved to save the PHI is what is given by this rule. These emergency are like Natural Disasters,

	Fire, System Failures etc.
Evaluation	This means to perform a technical and non technical evaluation on the standards that are implemented on this rule.
Business Associate Contracts and Other Arrangements	A business entity can transmit receive create EPHI from a covered entity but in this case it's the duty of the covered entity to make sure that the business entity will guard the security and integrity of the information.

Security Standards – Physical Safeguards

These are actions policies and procedures that are developed to protect the covered entities electronic information system and related building and equipments from natural disasters, unauthorized personnel intrusion. [53]

List of Standards under Physical Safeguards are as follows:

Physical Safeguards	Explanation
Facility Access Control	This rule implements the policies and procedures which will manage the authorized access to the building where sensitive patient information is present.
Workstation Use/ Security	This ensures that the workstation use should be strictly prohibited by non authorized personnel's, The workstation is an important key and all the patients' information can be accessed through it. Hence it's very critical to have correct access to it by persons.
Device and Media Controls	This means to implement such policies and procedures that will monitor the receipt and removal of hardware and any electronic media in and out of the facility.

Security Standards – Technical Safeguards

These are actions policies and procedures that are developed for the technology that is used to protect EPHI. [53]

List of Standards under Technical Safeguards are as follows:

Technical Safeguards	Explanation
Access Control	This means such policies and procedures to be implemented that it monitors the access to those software programs that deals with EPHI.
Audit Control	This means auditing any and every activity related to EPHI.
Integrity	To implement Policies and Procedures to

	implement the improper alteration and destruction of EPHI.
Person or Entity Authentication	**To implement such policies and procedures to verify that the person or entity that is accessing the EPHI is the one Claimed.**
Transmission Security	**This means to implement such security measures which will guard against any unauthorized access to EPHI that is transferred over electronic media.**

Security Standards Matrix (Appendix A of the Security Rule)

ADMINISTRATIVE SAFEGUARDS

Standards	Sections	Implementation Specifications (R)= Required, (A)=Addressable	
Security Management Process	§ 164.308(a)(1)	Risk Analysis	(R)
		Risk Management	(R)
		Sanction Policy	(R)
		Information System Activity Review	(R)
Assigned Security Responsibility	§ 164.308(a)(2)		
Workforce Security	§ 164.308(a)(3)	Authorization and/or Supervision	(A)
		Workforce Clearance Procedure	(A)
		Termination Procedures	(A)
Information Access Management	§ 164.308(a)(4)	Isolating Health Care Clearinghouse Functions	(R)
		Access Authorization	(A)
		Access Establishment and Modification	(A)
Security Awareness and Training	§ 164.308(a)(5)	Security Reminders	(A)
		Protection from Malicious Software	(A)
		Log-in Monitoring	(A)
		Password Management	(A)
Security Incident Procedures	§ 164.308(a)(6)	Response and Reporting	(R)
Contingency Plan	§ 164.308(a)(7)	Data Backup Plan	(R)
		Disaster Recovery Plan	(R)
		Emergency Mode Operation Plan	(R)
		Testing and Revision Procedures	(A)
		Applications and Data Criticality Analysis	(A)
Evaluation	§ 164.308(a)(8)		
Business Associate Contracts and Other Arrangements	§ 164.308(b)(1)	Written Contract or Other Arrangement	(R)

PHYSICAL SAFEGUARDS			
Standards	**Sections**	**Implementation Specifications** (R)= Required, (A)=Addressable	
Facility Access Controls	§ 164.310(a)(1)	Contingency Operations	(A)
		Facility Security Plan	(A)
		Access Control and Validation Procedures	(A)
		Maintenance Records	(A)
Workstation Use	§ 164.310(b)		
Workstation Security	§ 164.310(c)		
Device and Media Controls	§ 164.310(d)(1)	Disposal	(R)
		Media Re-use	(R)
		Accountability	(A)
		Data Backup and Storage	(A)
TECHNICAL SAFEGUARDS			
Standards	**Sections**	**Implementation Specifications** (R)= Required, (A)=Addressable	
Access Control	§ 164.312(a)(1)	Unique User Identification	(R)
		Emergency Access Procedure	(R)
		Automatic Logoff	(A)
		Encryption and Decryption	(A)
Audit Controls	§ 164.312(b)		
Integrity	§ 164.312(c)(1)	Mechanism to Authenticate Electronic Protected Health Information	(A)
Person or Entity Authentication	§ 164.312(d)		
Transmission Security	§ 164.312(e)(1)	Integrity Controls	(A)
		Encryption	(A)
ORGANIZATIONAL REQUIREMENTS			
Standards	**Sections**	**Implementation Specifications** (R)= Required, (A)=Addressable	
Business associate contracts or other arrangements	§ 164.314(a)(1)	Business Associate Contracts	(R)
		Other Arrangements	(R)
Requirements for Group Health Plans	§ 164.314(b)(1)	Implementation Specifications	(R)

POLICIES AND PROCEDURES AND DOCUMENTATION REQUIREMENTS			
Standards	**Sections**	**Implementation Specifications** (R)= Required, (A)=Addressable	
Policies and Procedures	§ 164.316(a)		
Documentation	§ 164.316(b)(1)	Time Limit	(R)
		Availability	(R)
		Updates	(R)

[**Fig. 18**] **Security Standard matrix**

Data Level Security

Security breaches are possible if the data is exchanged between different organizations. Organizations understand that it's very important to keep all the important data behind the firewall and then follow some rules and policies. Some of the policies and practices which can help ensure security of sensitive data are as follows:

1) Higher Management should take necessary steps and understand the importance of the problem.
2) Policies should be applied in practice. These policies should define everything from how the data should be stored to how it is accessed and how it's transmitted. These policies should be strict and well controlled by the management.
3) Systems where the sensitive data is stored should be behind a firewall. The threat to data is mostly from network. Hence it should be monitored very seriously. The data which is sensitive should net be allowed to transferred through global network. Tools should be installed in the facility which can monitor on the network and other sensitive patient health information data transfer.
4) Authorization and Authentication should be applied. Password systems should be made secure and users should be asked to change the password very frequently. Also users should be trained to follow the security measures and policies. All the authorization requests for users should be monitored and should be documented. [56 – 57]
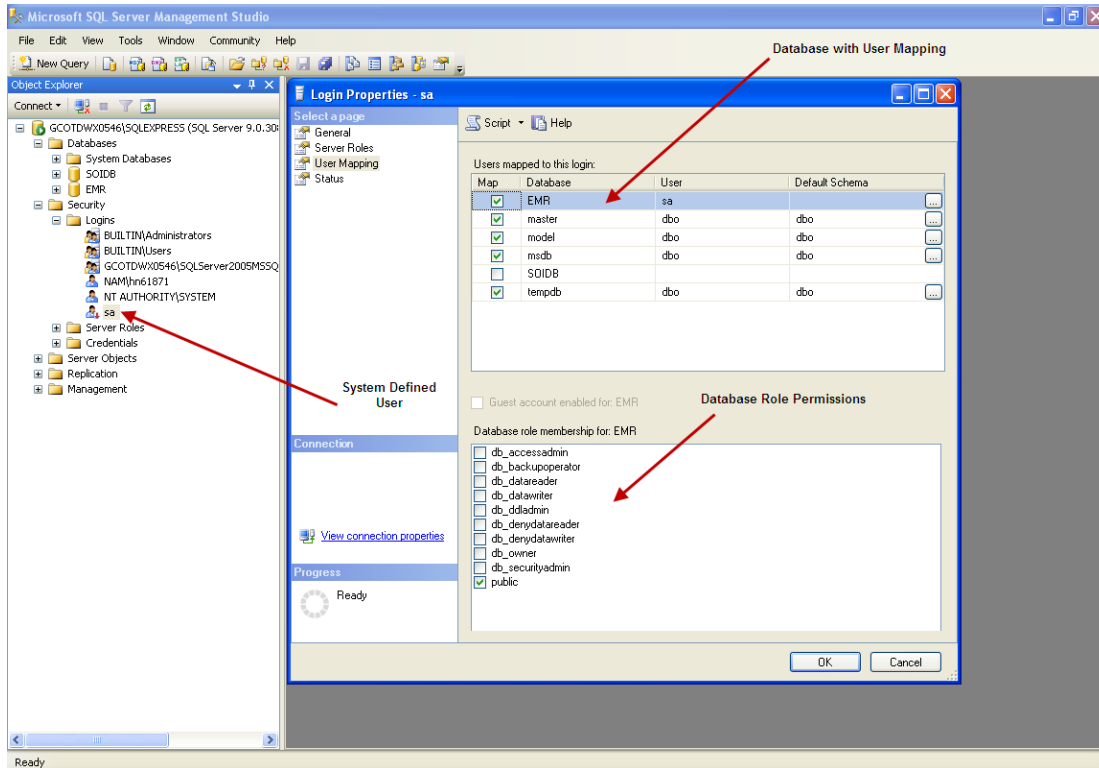
Below are the few methods by which security can be implemented at the data level.

- **Assigning Roles to the users for selective data view in SQL Server**
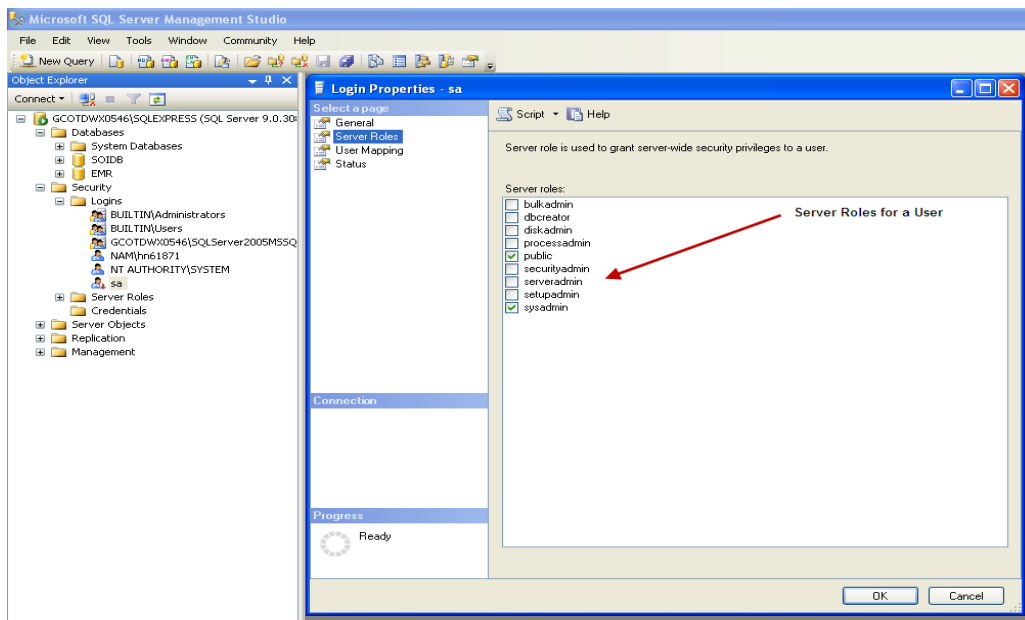
[**Fig. 19**] Assigning Roles to the users

- **Assigning users access to DB in SQL Server**

[**Fig. 20**] – **Assigning Users exclusively to operate on a DB.**

Organization level Security

There are many ways organization level security can be implemented. The main purpose here is to restrict unauthorized persons to access the organization resources. The different ways security can be implemented at an organizational level are as follows:

● Data backups are an important part of securing the data in case of any disaster or other loss. But the backups should be kept in place of highly secure locker room with very limited accessibility to persons.
● Disabling any data transfer to any external device like CD writing or USB drive. The best way to do is to disable any USB ports in the user's machine and there should not be any accessibility to any personal mails or messengers from where the data can be sent.
● Portable devices like laptops should be locked to its console on user's desk. The portable devices are very easy to steal hence they should be monitored and locked.

- There should be different access to the server room from where all the sensitive patient information data flows. It should be strictly accessible to only authorized persons.

- The whole facility should be under video surveillance so that any suspicious activity can be tracked.

- Printers should have limited accessibility and should be monitored so that any sensitive PHI should not be printed.

To achieve this security, identification cards or access cards should be assigned to the employees of the hospital and the office or the hospital can be security id accessed. This way any unauthorized person will be restricted from entering into the office. Also there can be security agents at the reception which can track the users in and out of the organization. Any visitors who enter into the hospital should be given badges and should be accompanied by the authorized personnel.

Next thing that can be done is to provide detail levels of security for the data. Like the users of the Sensitive patients data should be allowed to enter into the system via finger print login. [58 – 59]

3.3   HIPAA Unique Identifiers Rule

The National Provider Identifier (NPI) is a 10 digit unique identification standard for covered healthcare providers, Healthcare Clearing Houses and Health Plans. NPI should be used in all financial transactions & administrative tasks which are under the umbrella of HIPAA. This NPI does not contain any information about the Healthcare Provider like the state from where they belong etc. [60]

3.4   HIPAA Enforcement Rule

It contains provisions relating to Investigations and Compliance and imposing penalties for violating any HIPAA rules. It got implemented on March 16, 2006. The enforcement rule also defines the defense a covered entity may have in order to avoid the penalty. If the covered entity proves that the violation is not willful and was due to a reason or if the violation was not known to the covered entity then the covered entity is saved from the penalty. And to do this the covered entity has 30 days to respond. The maximum penalty for breach of any HIPAA rule ranges from $100 per violation and ranging up to $250,000 in a calendar year. [61]

3.5   Transaction and Code Sets Standards

Transactions are changing information between two entities. e.g. A physician office will send the claim transaction to a clearinghouse for release of the payment. HIPAA has formulated certain transactions which are standard for EDI (Electronic Data Interchange) for Health Care Data. [62]

These transactions are:

- Payment and Remittance Advice
- Claims and Encounter information
- Claim Status
- Referrals and Authorizations
- Eligibility
- Enrollment and disenrollment
- Premium Payment

As per the HIPAA rule if the covered entity performs any of these transactions electronically then they will have to follow set standards by HIPAA. This means that there will be a defined content and format by which information can be sent and that should be followed by any covered entity. Also HIPAA has formulated code sets which should be used in every transaction. [62]
Some of them are

- CPT-4 : Physicians Procedures
- CDT : Dental Terminology
- ICD-10 : Diagnostics and hospital inpatient procedures
- NDC : National Drug Codes

4 EMR Vendors

4.1   EMR Vendor Selection

Selecting an EMR system is a very challenging task as it involves a number of factors to be considered. To implement an EMR is a very expensive effort hence good research should be done before finalizing an EMR from a vendor. Also the system might interact with many other systems in the organization hence its important to review the system and the vendor authentication before moving forward. There are over 400 vendors in the market today which deal in EMR/ EMR systems. There are a few points that need to be considered before selecting an EMR system. [63 - 65]

Defining Needs:

EMR vendors can provide many features which will enhance the product and its cost. But many of the features might not be useful for the organization. It's very essential for a facility to decide its needs clearly and the way they can be achieved by the implementation of the EMR. The best way would be to create a functional checklist which will point out all the functional requirements as well as considering the present structure of the facility.

Selecting and Filtering Vendors:

Selecting a vendor is yet another crucial process which involves many steps to be considered. There are many vendor companies present in the market and to select amongst them is a challenge. A few things which might help in selecting and deciding vendors are:

- To see if the vendors are certified to develop and sell the EMR product.
- To get the product quotation from the vendors and analyzing the most beneficial one.
- To review functions provided by each vendor and selecting/ filtering functions that are useful to the facility.
- To attend demonstrations by different vendors so as to get a feel of the current features of today's market and how those can be implemented in the facility to increase the business and productivity of the organization. [63 - 65]

Certifications/ Associations/ Partners:

Before finalizing the EMR vendor it should be verified weather the vendor is certified to sell the EMR software. There are many certifications which a vendor should have and which proves the guidelines on which the EMR product is being prepared. A reference check should also be performed wherein asking other facilities and physicians about the pros and cons of a particular product. By analyzing the challenges of various people it can be

determined which vendor is best and which features should be present in an EMR system. [66 - 68] For example CCHIT certification.

It should be made sure that the vendor is CCHIT (Certification Commission for Healthcare Information Technology) certified in order to match the industry standard of the product.

The CCHIT is the only certification available currently which establishes testing programs which determine if the EMR or EHR are following the standards and is a nonprofit organization. CCHIT measures every product in three different areas mainly:

- **Functionality**: This includes creating a program which can support all the workflow at a physician's office.
- **Interoperability**: The program should have feature to interact i.e. Receive and send data, between different entities outside the system like Radiology, Labs, pharmacies etc,
- **Security**: The program should follow all the security and privacy rules of HIPAA to ensure the safety of PHI.

Cost Estimation:

Estimating the cost is a very crucial step in order to select an EMR product. Vendors provide many features for which there are charges but the stress should be given to only those which are beneficial for the facility. A cost matrix that should be prepared in order to evaluate the features v/s cost for each vendor. There are many factors that can be considered in order to finalize an EMR solution. These are as follows:

Hardware: This is a major cost that a facility needs to bear in order to implement an EMR solution. Hardware includes servers, computers and related accessories etc. It should be checked if the EMR solution provided by the vendor includes the Hardware or it's just the Software. The vendor may provide everything as a package which includes the software as well as hardware.
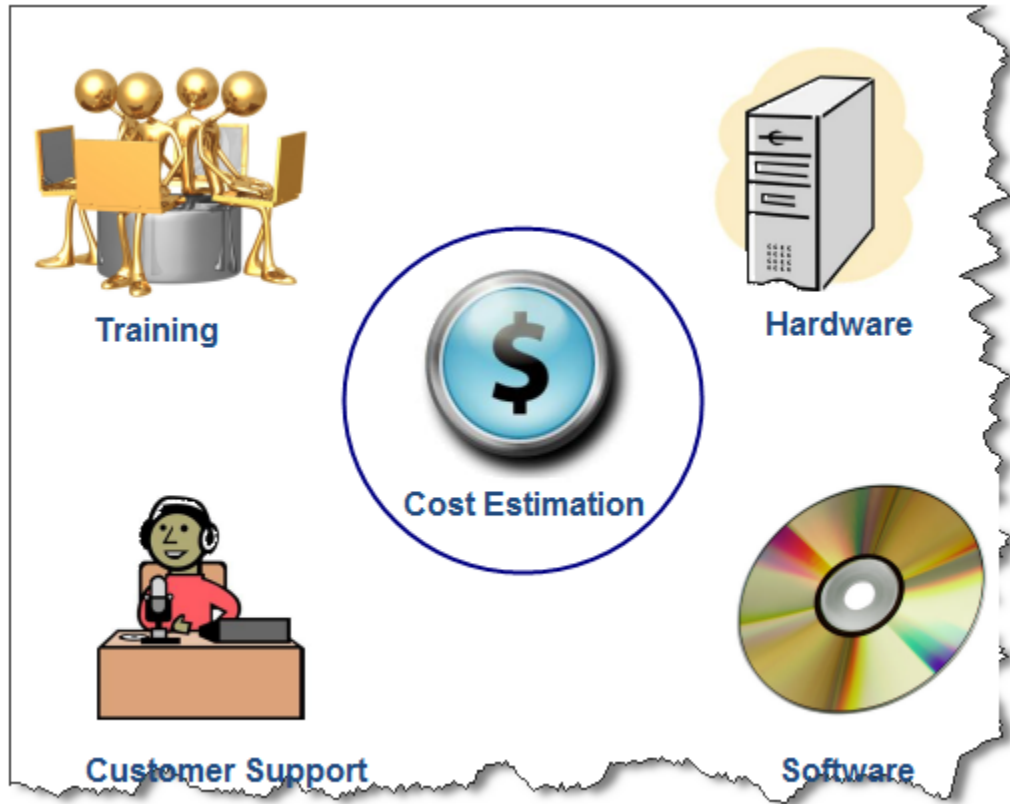
[Fig. 21] – Cost Estimation

Software: This is another entity of high cost. Everything depends on the software quality and its extensibility.

Maintenance/ Customer Service: With new EMR software the organization will also require maintenance and customer service for that software. Even if the organization has its own technical team, there is always requirement for technical and skilled team who knows the technicalities of the software for updates or problem solving. Maintenance and customer service fees are also very important points to be considered before selecting the vendor.

Training: This is yet another factor that adds to the cost as the vendor might ask for a high amount for training the workforce to use the EMR product. The training should be very user friendly and provided time to time. [63 - 65]

Miscellaneous Questions:

There are many miscellaneous questions which should be considered in order to determine the right EMR solution for your facility, like:

a. Is the EMR able to support many offices in case you are a hospital or if you have to access the information remotely?

b. Is the EMR able to support features to interact with different department which are of your interest like Radiology, Labs etc.?

c. Does the EMR have good charting and graphical quality images which are necessary for diagnosis and usability?

d. Does the EMR recognize hand written notes by physicians? This feature will reduce the work of doctor a lot as they can just write in their own style and feed it in the system?

e. Will the EMR support medical transcription by the use of voice recognition method?

f. Is the company CCHIT certified? If not then what are the measures for product quality?

g. How long the vendor is in the market?

h. Which are its biggest clients?

i. What is the license fees per physician/ facility?

j. What will be the maintenance costs?

k. Is the product compliant of HL7 messages?

l. What are the measures taken to follow HIPAA security and privacy rules?

m. Where is the product developed and where will the support present?

n. Will there be a team or a dedicated person for the maintenance?

o. Will there be newer version of the software if yes then will they be charged?

p. Which technologies are used in the product and use of those technologies?

q. Is the vendor partner with anyone like Microsoft Certified, CISCO certified, Oracle Certified etc.?

   [63 - 65, 69]

Feature of Appointment Scheduling:

This is a very important feature which is a great help to physicians and front desk persons who deals with the appointment of patients. Many EMR systems provide good appointment scheduling feature in the product either by developing it or by using a third party appointment scheduling feature. The scheduling helps the physician to determine the days, months and years appointments. [70 - 71]

Integrated V/S Modular EMR system:

There are two approaches to implement the EMR system in any facility. Either it can be the full change of the EMR system replacing all the functions in a physician's office or it can be modular approach wherein only few features are replaced by the EMR and rest works the same way as before. Both of the practices have their pros and cons. The EMR vendors examines the current office practice and determines which module is taking more time than usual and is not efficient and will replace only that practice with some modules of the EMR. In that case the problem is that the EMR system module should be flexible enough to interact with other entities in the office.

For example the EMR vendor finds that the transcription system is not efficient. It is tedious to send the documents to the transcriptionist and then get the electronic version of the document and then pass it on to other systems. Now if the new EMR system implements the whole transcription process of voice recognition then it will reduce the work but at the same time it needs to be determined whether the output of the EMR system can be recognized by other systems in the facility. Also this might not be as accurate as human transcriptionist. If the EMR system completely replaces the existing working system in an office then the hurdle might be training as well the working model will change. Also it will take a lot of time for the system to become stable and to be able to interact properly with other systems. [72 – 73]

Evaluating the EMR system:

For evaluating the EMR system, involvement of the workforce members is required who can analyze the functional and non functional requirement of the facility and can analyze how the new system will be a help to the business and productivity. The offering from the EMR vendor should also be considered in detail to filter out the non relevant features for the facility. Timelines should also be created by the higher workforce members who will help to access the success of the integration of the new EMR system.

[72 – 73]

4.2   **EMR Vendors Comparison**

There are more then 400 EMR vendors and to compare these vendors is a tough task. All Vendors have various different features to offer. It depends on the need of facility needs which vendor the facility should choose. [74]

KLAS is a very well known industry organization which deals in evaluating the EMR/ EHR systems. Many facilities trust KLAS system to evaluate the EMR/ EHR for their medical needs. [75] KLAS provides ranking of HER from the experience of various heath care facilities. Below are few figures from KLAS which give an evaluation on different types of EMR systems.

Acute Care EMR

Software products that provide core inpatient functionality, including CDR, order entry (including CPOE), results reporting, and/or clinician charting and documentation.

Rank	Previous Rank	Vendor/Product	Overall Score	Rating % Change	Konfidence Level	Buy Again	Has All Functionality Needed	Product Quality Rating
		Current Products§						
1	1	Epic EpicCare Inpatient	87.75	+3%	✓✓✓	99%	59%	7.91
2	2	Eclipsys Sunrise Clinical Manager	75.92	+2%	✓✓✓	89%	42%	7.18
3	4	MEDITECH C/S Enterprise Medical Record	73.67	0%	✓✓✓	75%	32%	6.92
4	3	McKesson Horizon Expert Orders/Doc.	73.64	0%	✓✓✓	84%	29%	6.75
5	6	Cerner Millennium PwrCht/PwrOrders/CareNet	72.68	+2%	✓✓✓	85%	39%	6.83
6	5	QuadraMed CPR	72.12	-1%	✓	67%	30%	7.04
7	7	Siemens Soarian Clinicals	71.88	+1%	✓✓✓	75%	23%	6.62
8	8	GE Centricity Enterprise Clinicals	64.54	+22%	✓✓	63%	9%	6.03
		Component [C], Superseded [S], Not Primary [NP] or Regional [R] Products§						
NA	NA	GE LastWord Clinicals* [S]	56.46	-7%	–	11%	0%	6.63
NA	NA	McKesson Paragon Clinicals* [NP]	63.25	NA	–	80%	0%	5.00
NA	NA	MEDITECH MAGIC Patient Care Inquiry [NP]	75.31	+4%	✓✓✓	79%	41%	6.94
NA	NA	QuadraMed Affinity Clinicals* [NP]	52.44	-18%	–	14%	8%	4.86
NA	NA	Siemens Invision Clinicals [S]	68.52	-5%	✓✓	64%	12%	6.62

The following chart includes products that meet minimum konfidence in a "Best in KLAS" market segment. The chart compares the products' overall score and konfidence level. For a listing of "Best in KLAS" market segments, go to www.KLASresearch.com/top_20. For definitions of KLAS konfidence levels, visit www.KLASresearch.com/konfidence.

*Preliminary scores do not meet KLAS' minimum konfidence level. For definitions of KLAS konfidence levels, visit www.KLASresearch.com/konfidence.
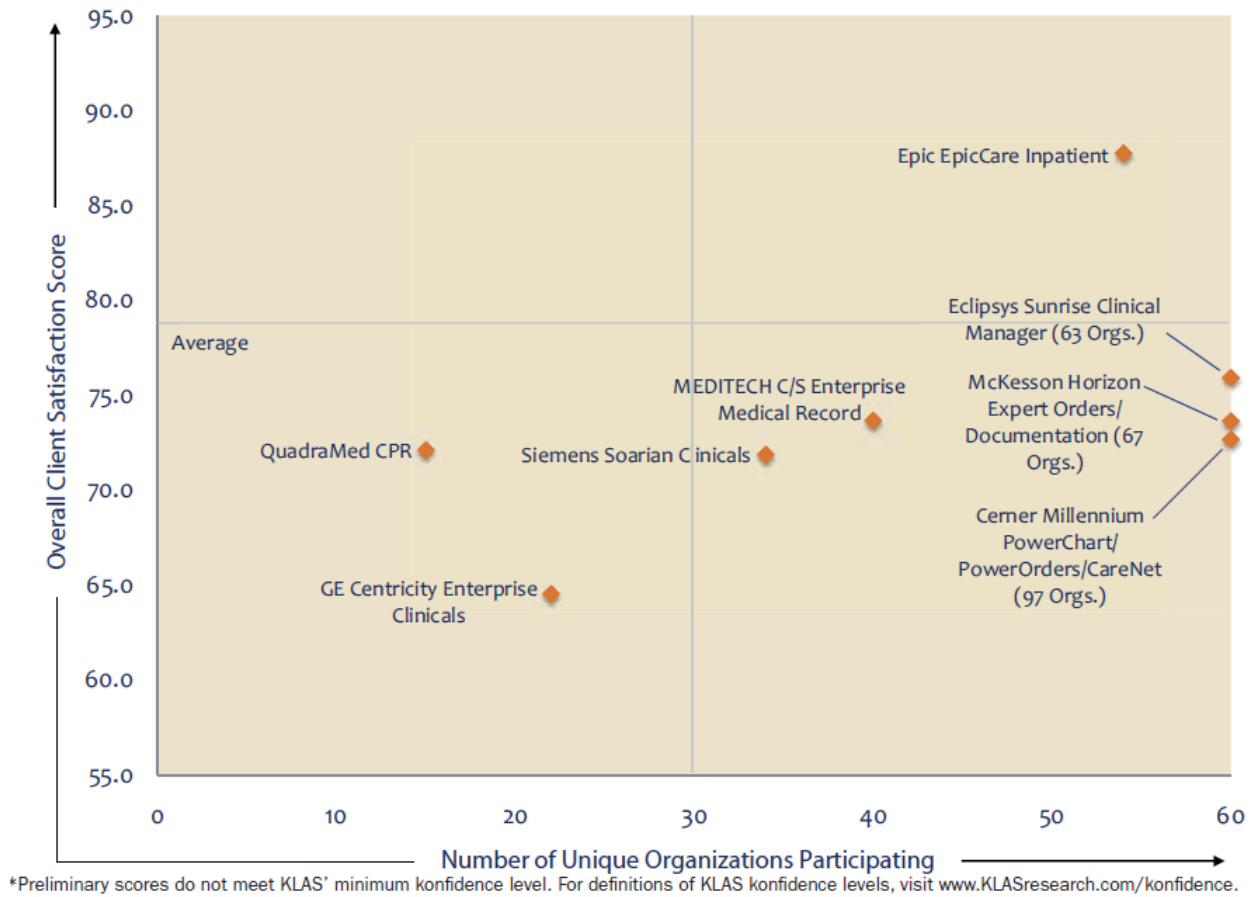
[**Fig. 22**] – **Acute Care EMR**

Ambulatory EMR (Over 100 Physicians)

Software solutions focused on providing physician documentation, nurse charting, orders, prescriptions and/or EMR functionality for the ambulatory setting.

Rank	Previous Rank	Vendor/Product	Overall Score	Rating % Change	Konfidence Level	Buy Again	Has All Functionality Needed	Product Quality Rating
		Current Products§						
1	1	Epic EpicCare Ambulatory	89.34	+1%	✓✓✓	100%	67%	8.10
2	2	NextGen EMR	72.78	-7%	✓✓	85%	17%	7.00
3	NA	eClinicalWorks EMR	70.90	-6%	✓✓	67%	38%	6.95
4	4	GE Centricity EMR	70.28	-7%	✓✓	72%	8%	6.59
5	3	Allscripts Enterprise EHR	66.28	-13%	✓✓✓	79%	21%	6.14
6	5	Cerner Millennium PowerChart Office	59.05	0%	✓✓	63%	15%	5.54
NA	NA	Eclipsys Sunrise Ambulatory Care Manager*	68.63	NA	–	75%	17%	5.75
NA	NA	MED3000 IC Chart*	63.19	-17%	–	67%	17%	5.82

The following chart includes products that meet minimum konfidence in a "Best in KLAS" market segment. The chart compares the products' overall score and konfidence level. For a listing of "Best in KLAS" market segments, go to www.KLASresearch.com/top_20. For definitions of KLAS konfidence levels, visit www.KLASresearch.com/konfidence.
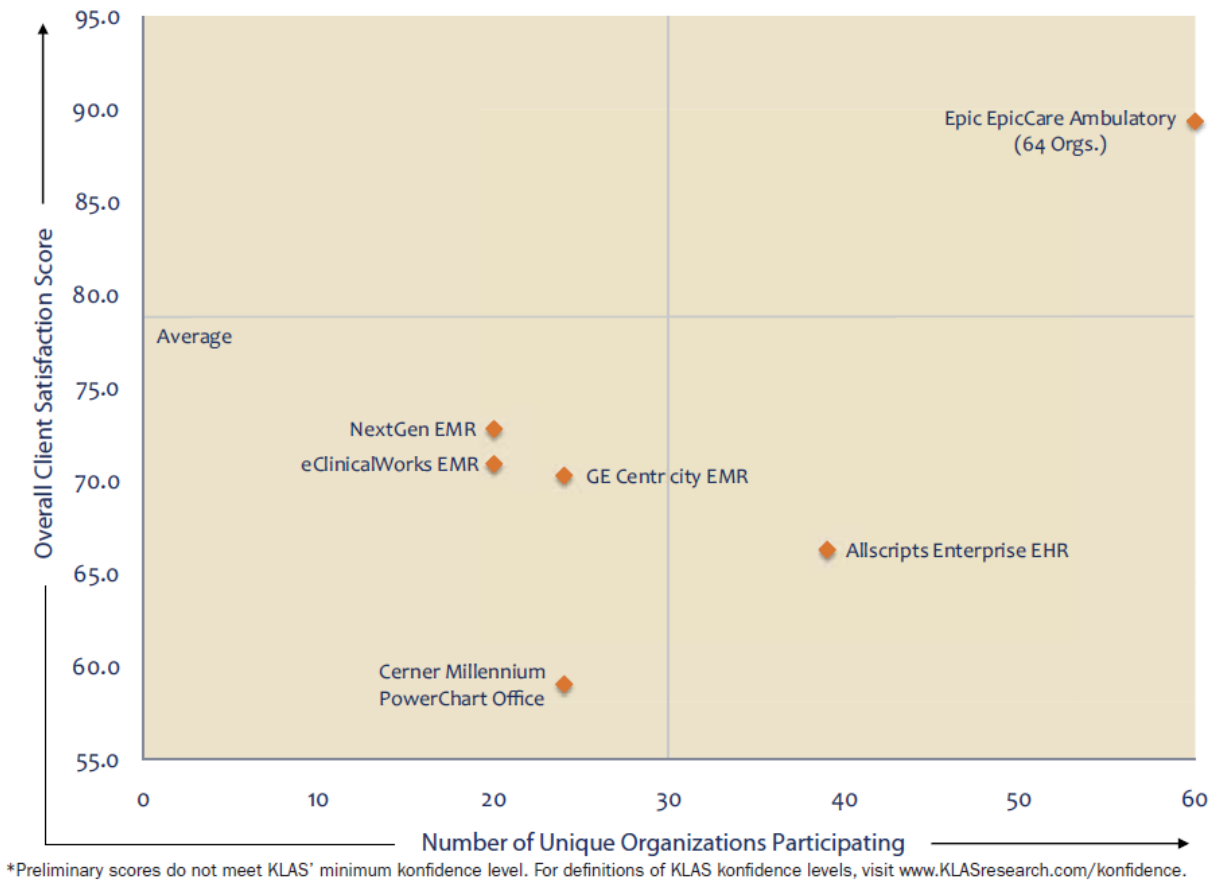
[**Fig. 23**] – **Ambulatory EMR**

PACS

Picture archiving and communication system. Software that archives digital images and provides a platform for displaying and transmitting images for physician review.

Rank	Previous Rank	Vendor/Product	Overall Score	Rating % Change	Konfidence Level	Buy Again	Has All Functionality Needed	Product Quality Rating
Current Products§
1	1	GE Centricity PACS-IW	87.76	-2%	✓✓	97%	68%	8.09
2	3	Philips iSite	85.27	+2%	✓✓✓	97%	62%	7.93
3	6	McKesson Horizon Medical Imaging	85.24	+3%	✓✓✓	97%	67%	7.92
4	5	AMICAS PACS	83.22	0%	✓✓	92%	51%	7.45
5	2	FUJIFILM Synapse	83.10	-3%	✓✓✓	89%	71%	7.52
6	4	DR Systems Unity	82.88	-1%	✓✓	84%	58%	7.75
7	NA	Sectra PACS	82.73	0%	✓	75%	59%	7.63
8	8	Carestream PACS	78.00	+1%	✓✓	79%	52%	7.62
9	7	Agfa IMPAX	77.11	-1%	✓✓✓	88%	57%	7.14
10	9	GE Centricity PACS	69.02	-9%	✓✓✓	65%	43%	6.53
11	10	AMICAS RadSuite (Emageon)	66.64	-7%	✓	60%	27%	6.00
12	11	Cerner Millennium ProVision	66.11	-1%	✓	71%	41%	6.09
13	12	Siemens syngo Imaging	65.71	+2%	✓✓	58%	39%	6.14
NA	NA	Intelerad IntelePACS*	91.14	+1%	–	100%	43%	8.00
NA	NA	Merge Healthcare Fusion*	59.10	NA	–	45%	45%	5.55
NA	NA	NovaRad NovaPACS*	77.24	-8%	–	86%	63%	7.00
Component [C], Superseded [S], Not Primary [NP] or Regional [R] Products§
NA	NA	Siemens SIENET* [S]	54.47	+2%	–	44%	13%	5.20

The following chart includes products that meet minimum konfidence in a "Best in KLAS" market segment. The chart compares the products' overall score and konfidence level. For a listing of "Best in KLAS" market segments, go to www.KLASresearch.com/top_20. For definitions of KLAS konfidence levels, visit www.KLASresearch.com/konfidence.
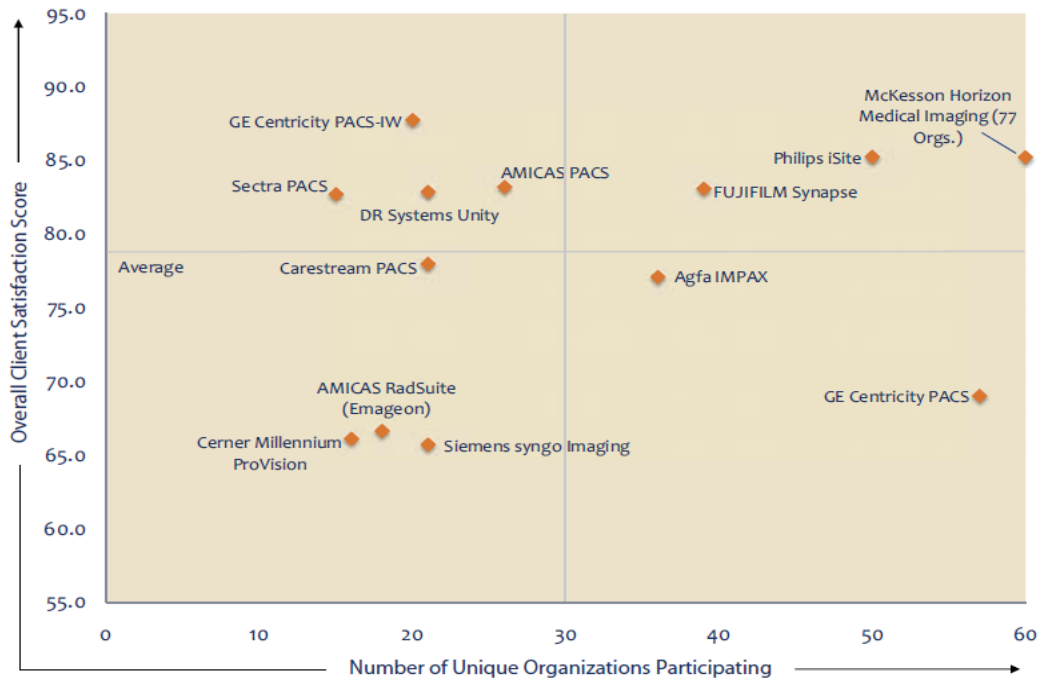
*Preliminary scores do not meet KLAS' minimum konfidence level. For definitions of KLAS konfidence levels, visit www.KLASresearch.com/konfidence.

[Fig. 24] - PACS

Patient Accounting and Patient Management

Software products that provide core inpatient functionality, including patient management (ADT), patient accounting (billing and A/R), basic scheduling, and/or general financials.

Rank	Previous Rank	Vendor/Product	Overall Score	Rating % Change	Konfidence Level	Buy Again	Has All Functionality Needed	Product Quality Rating
		Current Products§						
1	1	Epic Resolute Hospital Billing	88.32	+3%	✓✓✓	98%	68%	8.15
2	2	QuadraMed Affinity Financials	79.01	-6%	✓✓	84%	66%	7.64
3	4	McKesson STAR Financials	77.14	+4%	✓✓	85%	59%	7.18
4	3	MEDITECH C/S Patient Accounting/ADT	76.20	0%	✓✓	76%	54%	7.04
5	5	GE Centricity Business (Hospital)	75.66	+4%	✓✓	88%	52%	7.26
6	6	Eclipsys Sunrise Patient Financials	75.01	+5%	✓	83%	39%	7.08
NA	NA	Cerner Millennium ProFit*	66.95	+7%	–	58%	18%	6.08
NA	NA	IntraNexus SAPPHIRE*	70.75	-4%	–	70%	13%	7.20
NA	NA	Keane Patcom*	72.16	0%	–	75%	50%	6.92
NA	NA	Siemens Soarian Financials*	69.57	NA	–	83%	15%	6.36
		Component [C], Superseded [S], Not Primary [NP] or Regional [R] Products§						
NA	NA	McKesson HealthQuest [S]	76.72	+2%	✓	93%	43%	7.21
NA	NA	McKesson Paragon Financials* [NP]	66.38	NA	–	83%	33%	5.60
NA	NA	McKesson Series Financials* [S]	78.51	+2%	–	70%	25%	8.00
NA	NA	MEDITECH MAGIC Patient Accounting/ADT [NP]	76.16	+1%	✓✓	78%	53%	7.28
NA	7	Siemens Invision Financials [S]	69.16	+2%	✓✓✓	66%	41%	6.87
NA	NA	Siemens MedSeries4 Financials [NP]	72.46	0%	✓✓	74%	29%	6.76

The following chart includes products that meet minimum konfidence in a "Best in KLAS" market segment. The chart compares the products' overall score and konfidence level. For a listing of "Best in KLAS" market segments, go to www.KLASresearch.com/top_20. For definitions of KLAS konfidence levels, visit www.KLASresearch.com/konfidence.
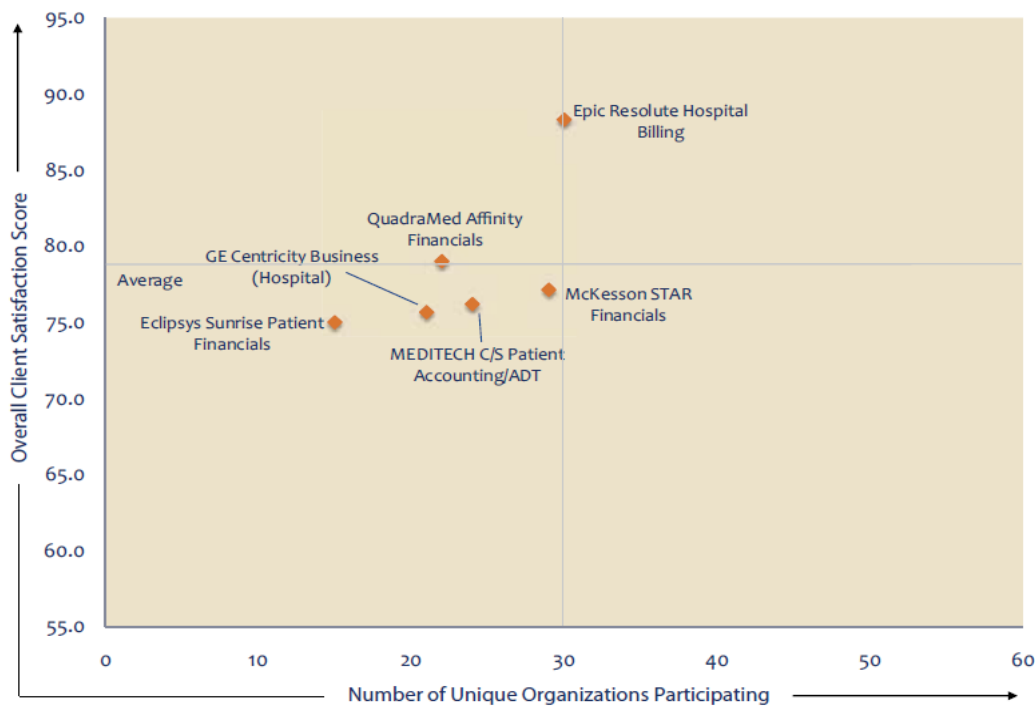
*Preliminary scores do not meet KLAS' minimum konfidence level. For definitions of KLAS konfidence levels, visit www.KLASresearch.com/konfidence.

[Fig. 25] – Patient Accounting and Patient Management

Clinical Implementation Principal

Engagements in which a professional services firm (PSF) assisted a provider in implementing inpatient EMR, ambulatory EMR (25+ physician practices only), ED, OR, or pharmacy applications by providing guidance, expertise, tools, methodology, and resources. The PSF played a major role, had specific deliverables associated with these engagements, and completed a measurable portion of the work. Various is used when a firm has implemented a vendor or vendors only once.

Rank	Previous Rank	Vendor/Product	Overall Score	Rating % Change	Konfidence Level	Buy Again	Money's Worth	Real Problem Resolution
		Current Products§						
1	4	ACS [Epic, McKesson, Siemens and Various]	87.8	+9%	✓	100%	7.71	7.86
2	3	Deloitte Consulting [Epic and Various]	87.6	+6%	✓	90%	7.50	8.20
3	NA	CTGHS [Cerner, Epic and Various]	87.4	-1%	✓	100%	7.70	7.73
4	2	Epic [Epic Only]	82.4	-2%	✓✓	100%	7.40	6.82
5	5	Cerner [Cerner Only]	82.2	+4%	✓✓✓	100%	7.38	7.44
6	NA	Accenture [Cerner, Epic and Various]	77.9	+2%	✓	75%	6.88	7.63
7	1	Dell Perot Systems [Cerner, Meditech and Various]	76.2	-10%	✓	67%	7.13	6.89
8	7	McKesson [McKesson Only]	71.8	-2%	✓✓	87%	6.13	6.21
9	8	Eclipsys [Eclipsys Only]	68.6	-5%	✓✓✓	84%	6.53	6.09
10	9	CSC [Eclipsys, Epic and Meditech]	62.0	-14%	✓	50%	5.63	6.06
11	6	Siemens [Siemens Only]	60.9	-20%	✓	70%	6.30	5.90
NA	NA	Coastal Healthcare Consulting [GE Only]*	97.3	+1%	–	100%	8.40	8.80
NA	NA	Cumberland [Allscripts and Various]*	77.8	+3%	–	75%	6.00	6.25
NA	NA	GE [GE Only]*	77.7	+8%	–	100%	7.00	7.00
NA	10	IBM [Cerner and Various]*	75.4	+9%	–	50%	6.50	7.50
NA	NA	Vitalize Consulting Sol. Inc. [Eclipsys and Various]*	82.8	NA	–	100%	7.50	8.25

The following chart includes products that meet minimum konfidence in a "Best in KLAS" market segment. The chart compares the products' overall score and konfidence level. For a listing of "Best in KLAS" market segments, go to www.KLASresearch.com/top_20. For definitions of KLAS konfidence levels, visit www.KLASresearch.com/konfidence.
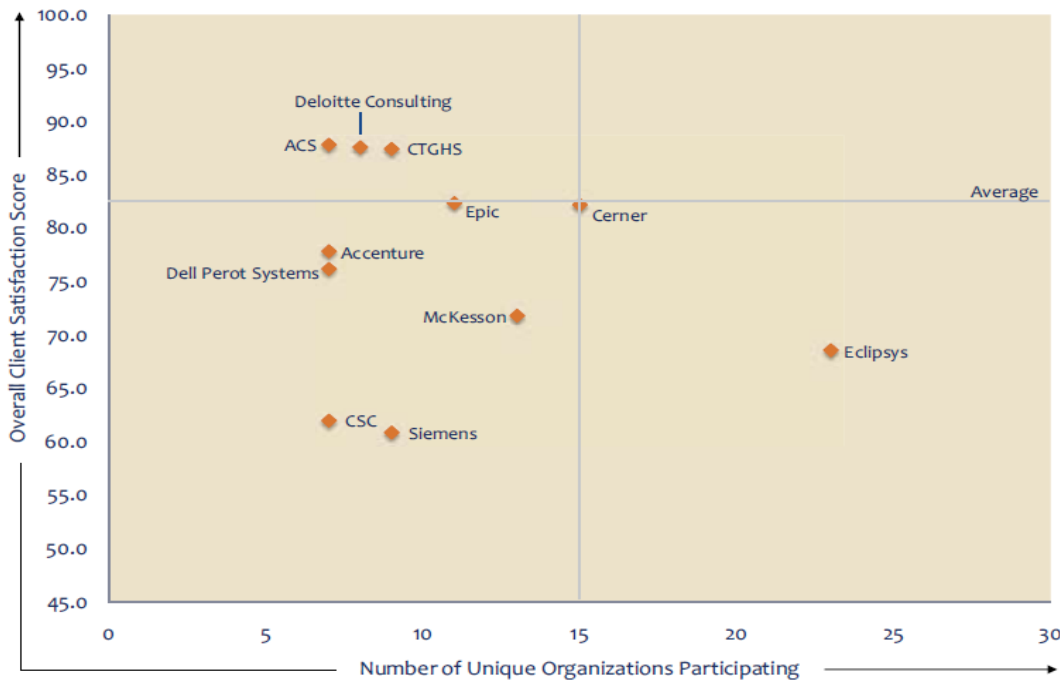
*Preliminary scores do not meet KLAS' minimum konfidence level. For definitions of KLAS konfidence levels, visit www.KLASresearch.com/konfidence.

[Fig. 26] – Clinical Implementation Principle

KLAS ranking of EHR programs for small medical practices[1]

Vendor and product	Total score (out of 100)	Product/ technology indicators (1 to 9)	Service indicators (1 to 9)	Success indicators[2] (1 to 9)	Business indicators[3]	Certified by CCHIT?
eClinicalWorks	91.7	8.0	7.9	8.2	98%	Yes
e-MDs Chart	88.5	7.6	7.7	7.9	95	Yes
Greenway Medical PrimeSuite	85.6	7.6	7.6	7.6	89	No
GE Centricity	83.6	7.5	7.5	7.4	86	Yes
Misys EMR[4]	83.3	7.4	7.4	7.3	87	Yes
MediNotes Charting Plus[5]	82.2	7.3	7.2	7.4	85	No
Allscripts HealthMatics EHR[6]	80.6	7.2	7.1	7.2	83	Yes
Emdeon Intergy EHR	78.2	7.1	6.9	7.0	80	Yes
NextGen EMR	77.4	7.0	6.9	6.7	80	Yes
Practice Partner Patient Records[7]	76.3	6.9	6.5	6.7	81	Yes

[1] Defined as practices with one to five doctors.

[2] Success indicators look at "factors that span the expectations before and after the sale."

[3] Business indicators are "measures of business value." Expressed as a percentage.

[4] Some vendors call their programs EMRs; others, EHRs.

[5] Since KLAS surveyed users, MediNotes has changed the name of its program from Charting Plus to MediNotes e (as in the lowercase letter "e").

[6] A4 Health Systems, the company that originally developed HealthMatics EHR, was acquired by Allscripts earlier this year.

[7] Practice Partner was formerly known as Physician Micro Systems.

Source: Table includes data from KLAS Enterprises and Certification Commission for Healthcare Information Technology (CCHIT)

[Fig. 27] – KLAS Ranking

A few EMR/HER market players of the industry and there features are discussed below.

A.   GE Healthcare – Centricity EMR

GE Healthcare is a big name in Healthcare Market and its product Centricity EMR is one of the famous ones. It was formerly known as Logician. There are three main products from GE for healthcare. [76 - 81] These are:

- Centricity EMR
- Centricity EMR for Specialty Care
- Centricity Practice Management (PM)

Certifications:

- CCHIT Certified
- National Committee of Quality Assurance (NCQA) for Diabetes Physician Recognition Program

Some Features of the Software:

a.   ePrescribing – Electronically submit prescriptions by use of wither sure scripts or RxHub. This feature will eliminate a lot of errors which can be caused by written prescriptions from physicians.

b.   Electronic submission of renewal requests by pharmacy or mail order is directly sent to centricity desktop where the provider can either accept or reject it. These can free up a lot of resources whose work is to answer patients or pharmacies phone or faxes.

c.   Check of patient's eligibility can be viewed online. Also the patient's history of prescriptions can be viewed by the provider.

d.   Product is developed as a Web Application keeping in mind the Portability for physicians and other members. This is a really important feature wherein the physician can log in anywhere to access the records.

e.   There are wide ranges of decision support tools which help to decide many factors while reviewing patient's details.

f.   Effective patient's disease search which allows searching patients with similar symptoms/ disease and hence reviewing the possible medications for patient.

g.   Following of ICD-9 Code (**The International Classification of Diseases**) which is developed by WHO. In this each patient symptoms and procedure is identified by ICD-9 code.

h.   Build in Evaluation and management module which helps in coding accuracy.

Goods and Bad of the Software:

Goods	Bad
The interface has logic and clarity.	Lot of emphasis on data discretion and categorization because of which it's a little complicated.
On site training services facility and access to community to discuss Best Practices used.	Web site is really confusing and no reading material is provided

Screenshots:

Department Management: To manage the cardiology Department
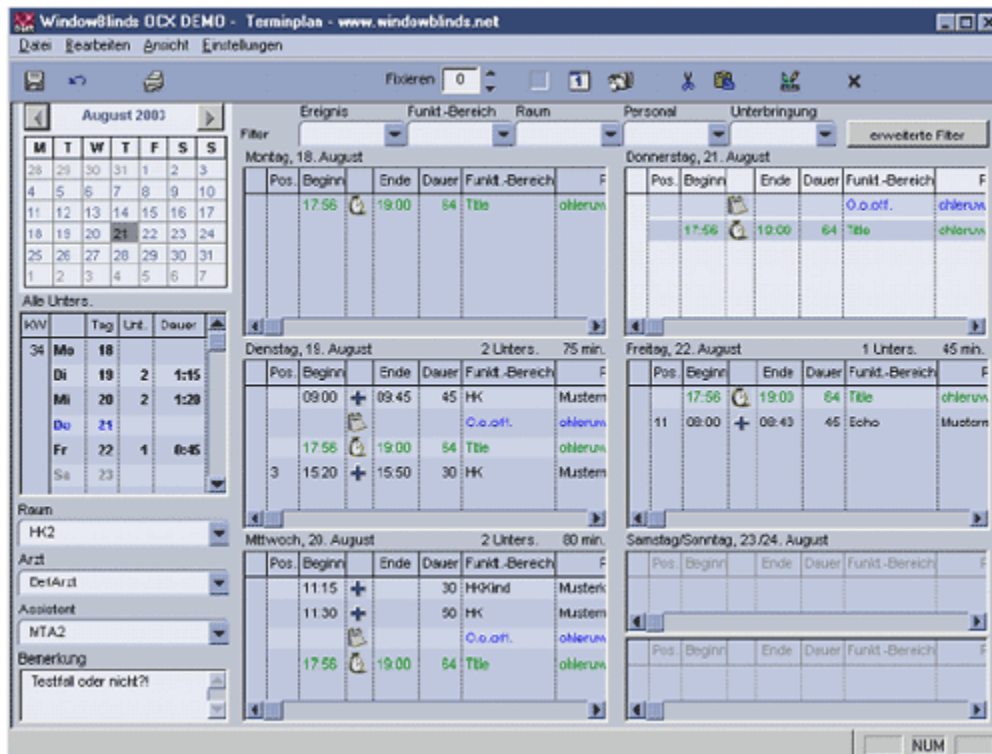
[Fig. 28] – Department Management

Workflow Management

Manages patient level admissions to and fro from the cardiology department

[**Fig. 29**] – **Workflow Management**

Patient Management:

To manage the cardiac history of patients

[**Fig. 30**] – **Patient Management**

Clinical Notification System

[Fig. 31] – Clinical Notification

B.   ABRAXAS EMR

[**Fig. 32**] – **Partners**

Location: Irvine, CA

Products: Abraxas EMR & Abraxas PM

Abraxas is a subsidiary of Ophthalmic Imaging Systems, a leader in Ophthalmic Digital Imaging. [82 - 83]

List of Features:

1.   **Attractive Room View**
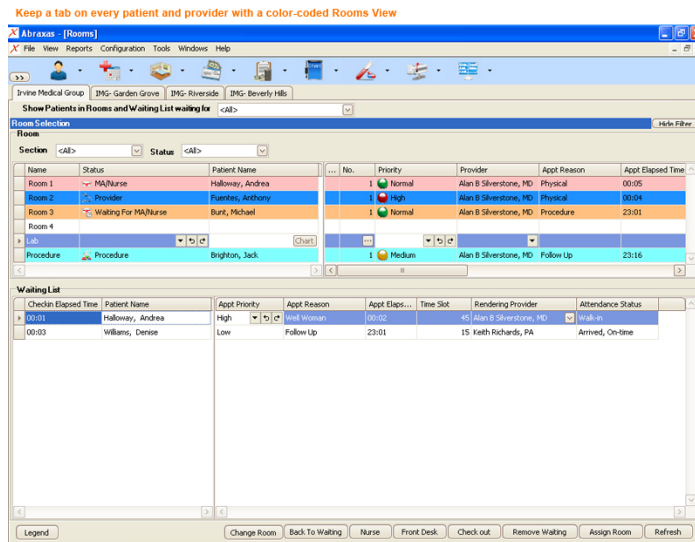
Overview of Patients & provider workflow with color coding. Presenting real time patient status like in waiting room, examination room etc.

[Fig. 33] – Active Room View

2.   **Multiple Options in Charting and Multiple Access**
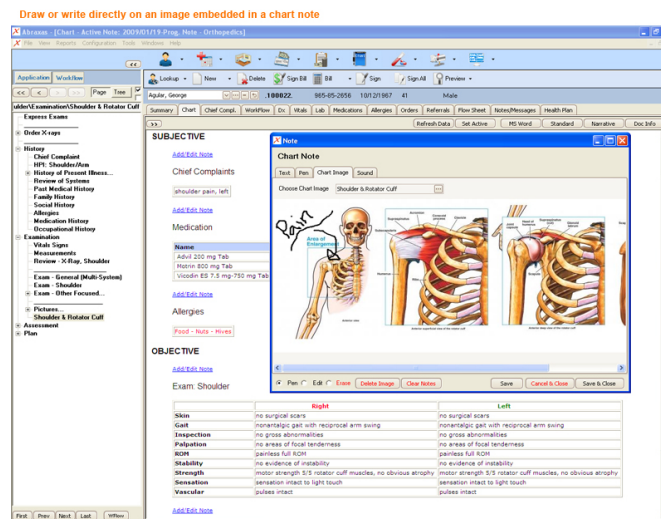
Like using pen or keyboard to write on the images itself in the tablet pc. Also multiple office or physicians can open the same chart simultaneously. Feature of using shortcuts to access charts makes it easy for operating.

[Fig. 34] – Multiple Access

3.   **Voice to patients chart**

Patient's notes or Physician notes can be attached as voice to the patients chart.

4. **Electronic Prescription**

Reliable transmission and delivery of prescription, medical history, drug eligibility etc., using sure scripts association.

5. **Drug Allergy and Interaction**

Using database of First Data Bank drug allergy and drug to drug interaction is maintained.

6. **Summary at a Glance**
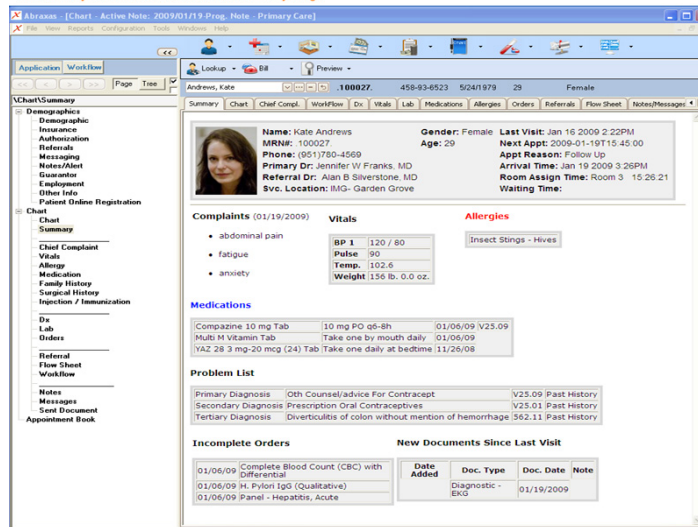
To view patients summary at a glance.

[Fig. 35] – Summary View

7. **Clinical Flow Sheets**
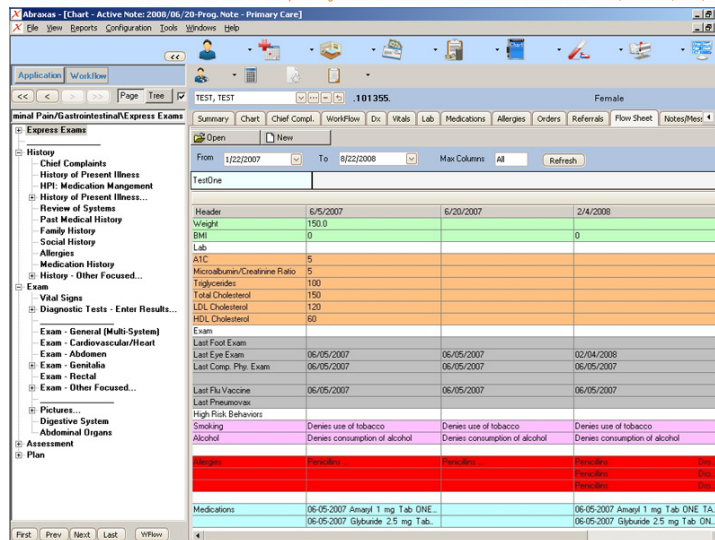
To integrate patients data from different modules and summarizing it in order to come up with better results. Like in case of diabetic patient, the data from everywhere like lab results, medications; vitals etc can be pulled to display one common result.

[Fig. 36] – Flow Sheets

8. Alerts and Remainders
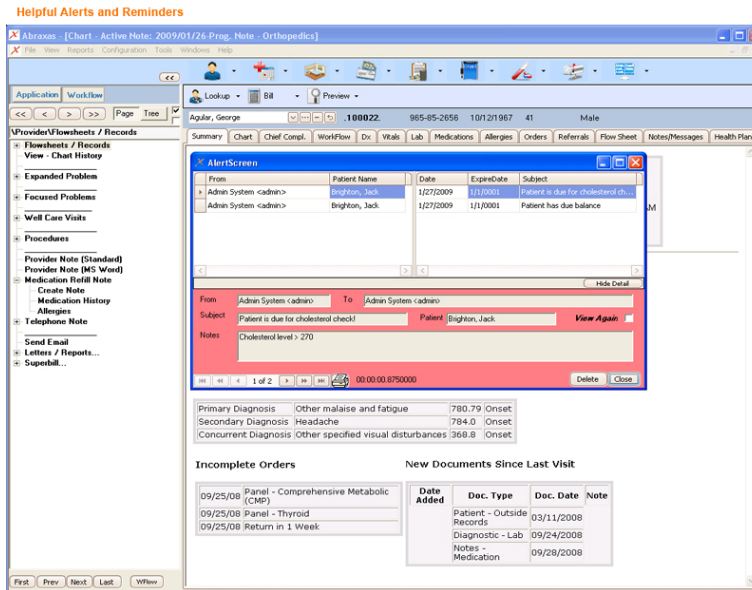
To improve quality using different alerts like conditional, disease and health.

[**Fig. 37**] – **Alerts and Remainders**

9. Electronic Orders

To get and send data to labs electronically like Quest Diagnostics and Lab Corp. Also used to Graph Lab results for trending purpose. Creates compliancy letters for the orders which are past due so as to maximize patient compliancy with treatment orders.
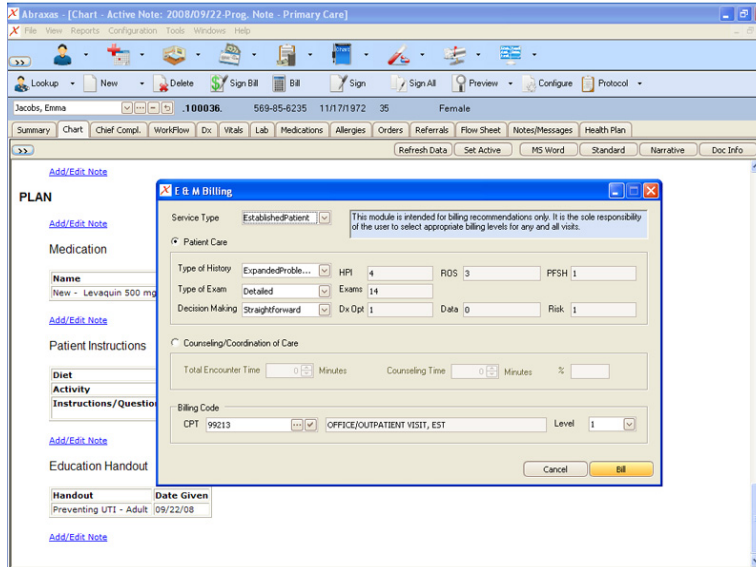
10. Document Management and Routing
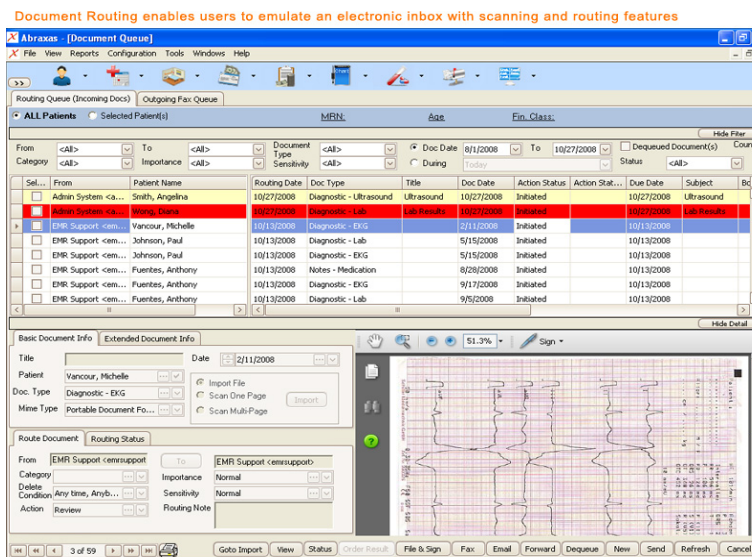
Any document which is scanned can be attached to the patients charts like radiology images, reports etc.

[**Fig. 38**] – **Document Management**

11. E&M Coding

To ensure compliance and proper billing CPT selection for each service is stored using the integrated E&M tool

[Fig. 39] – E&M Coding

12. Personal Dashboard View
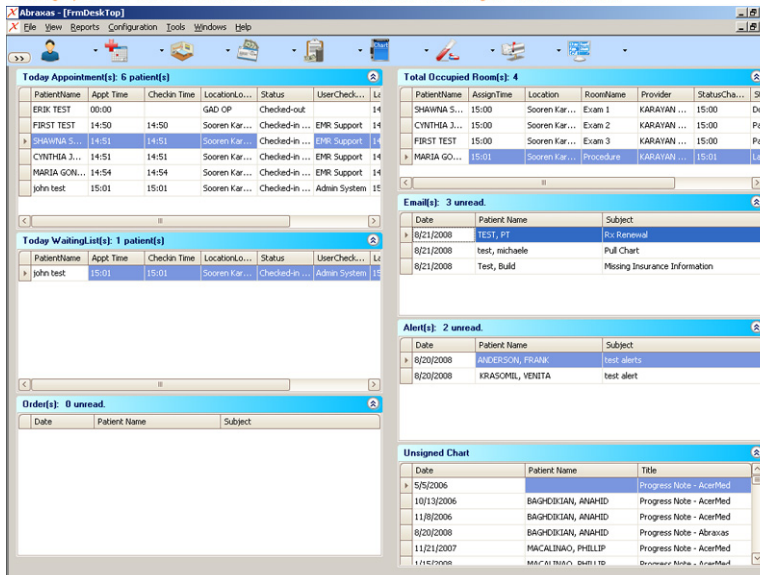
To get the current view of the system at one glance.

[Fig. 40] – Dashboard

C.   E Clinical Works

Products:

A.   eClinical EMR

B.   Enterprise management Patient Portal

C.   Enterprise Practice Management

D.   Electronic Health eXchange [74, 81]

Awards/ Certificates/ Facts/ Associations:

A.   eClinical works has been rated best EMR software product by KLASS

    System for small medical practices.

B.   Its EMR system is being deployed in all 50 states with more than 30,000 providers.

C.   Company has 98.9% renewal rate.

D.   Magazines Inc 500 list of fastest growing companies in 2008-2007. Employees more than 1000 people.

E.   Associated with Healthcare Clearinghouses and Direct Payers [74, 81]

[Fig. 41] – **Partners**

F.   Affiliated to Appointment Reminder Systems

[Fig. 42] – Affiliations

G. Association with Medical Devices/ Technology Devices, Decision Support/ Clinical Content, Industry Affiliations

[Fig. 43] – Associations

List of Features:

The GUI is divided by office tasks like Font office, mid office and back office.

The front office has the following modules: Receptionist, Patient, Scheduling, Registry, and Workflow.

Mid office has following Modules: Electronic Charts, Nurses, Doctors, Pharmacy, Labs, and Devices.

Back Office has following Modules: Billing and payment

General Modules: Document Management, Patients Portal

Some Unique Features of the Software:

i. Front Office module has a Telephone Management feature by which the calls can be managed or redirected.

j.   Front Office has the patients Flow Monitor which automatically determines the patients flow and its time in/ out.

k.   Mid Office Module has the handwriting reorganization feature which is really useful for the staff to feed in the data to the system.

l.   Mid office has Protocol Alerts for various things like Age, Gender etc.

m.   Mid office has Education module by which information for the patients and Rx can be generated.

n.   The product has feature by which one can write comments on images or x-rays. [74, 81]

Goods and Bad of the Software:

Goods	Bad
The system interfaces with a lot of major hospital Networks like Siemens and Meditech.	*The GUI is not consistent and all the modules have different look and feel.*
The system has a unique way of grouping tasks by jobs title as oppose to presenting all the tasks to each user.	*There are a lot of pop ups for displaying the information which is quite cumbersome to handle.*
Refined Search and Alerts for Patients.	*Color combinations are very bright.*
Features like handwriting recognition, patients flow monitor etc are very robust and unique.	

Screenshots of Product
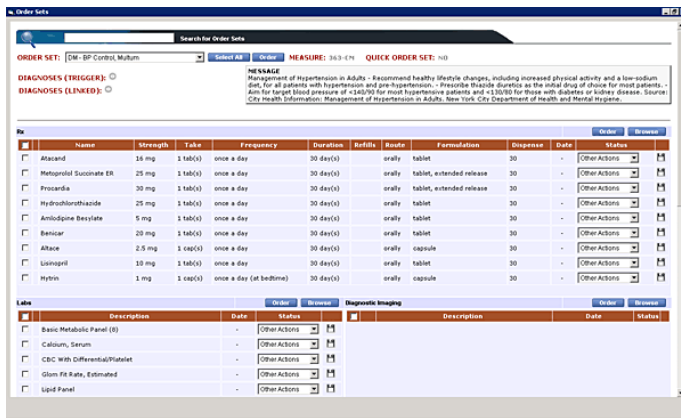
1. *Clinical Decision Support System*
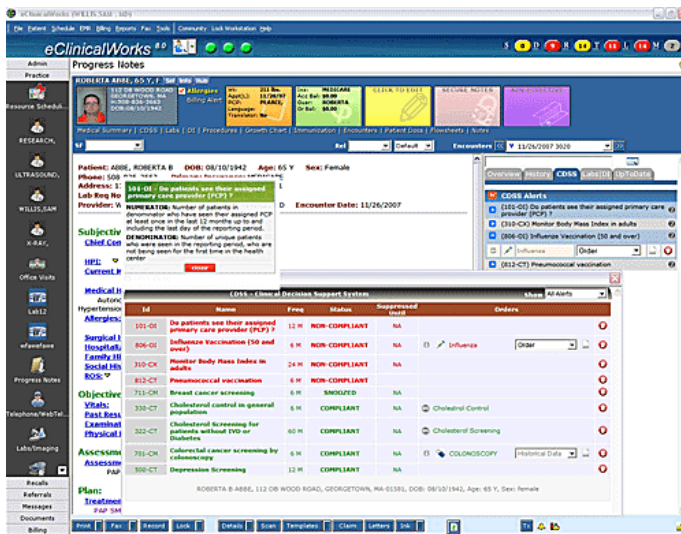
Design to develop clinical measures and new ways of improving chronic care and preventive care. It measures quality of patient care based upon build in query measure definitions.
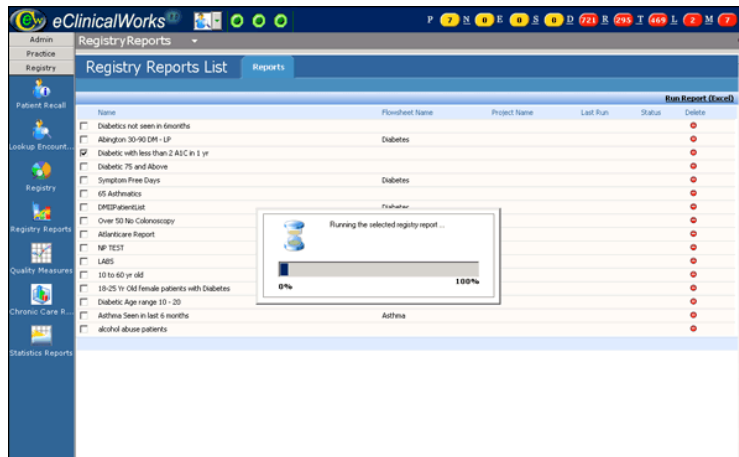
[**Fig. 44**] – **CDSS**

2. **Order Sets**

These are divided customizable treatment templates based on patient diagnosis.

[**Fig. 45**] **– Order Sets**

3. **Reporting**

Reporting based on various criterias to view the data more efficiently and logically.

[**Fig. 46**] **– Reporting**

4. E-Prescribing

To submit or refill prescription directly to a pharmacy.

[**Fig. 47**] **– E-Prescribing**

5. Progress Notes

Generates clean and easy to read progress notes or consultations and this is used to improve communication between different physicians.

[**Fig. 48**] **– Progress Notes**

COST

There are two price models:

Model 1   Upfront Price for EMR/ Practice Management

10,000 For first provider and then 5,000 for additional.

Maintenance and support fees are additional.

Training and implementation services cost can be found by contacting sales

Upfront Price for EMR only

$7,500 for the first provider and $4,500 for additional

Maintenance and support fees are additional.

Model 2   Subscription Pricing for EMR/ Practice Management

$400 per month/ Provider

Maintenance and Support fees is included in monthly fees

Training and implementation services cost can be found by contacting sales

Subscription Pricing for EMR only

$250 per month per provider

Maintenance and Support fees is included in monthly fees

5 World View of EMR

EMR concept and technology brings different views and opinion of people from different areas. Some find EMR very beneficial and a step to better and organized healthcare but others find it difficult and not so effective. [84 – 85] Below are the views of people from a few different areas of society:
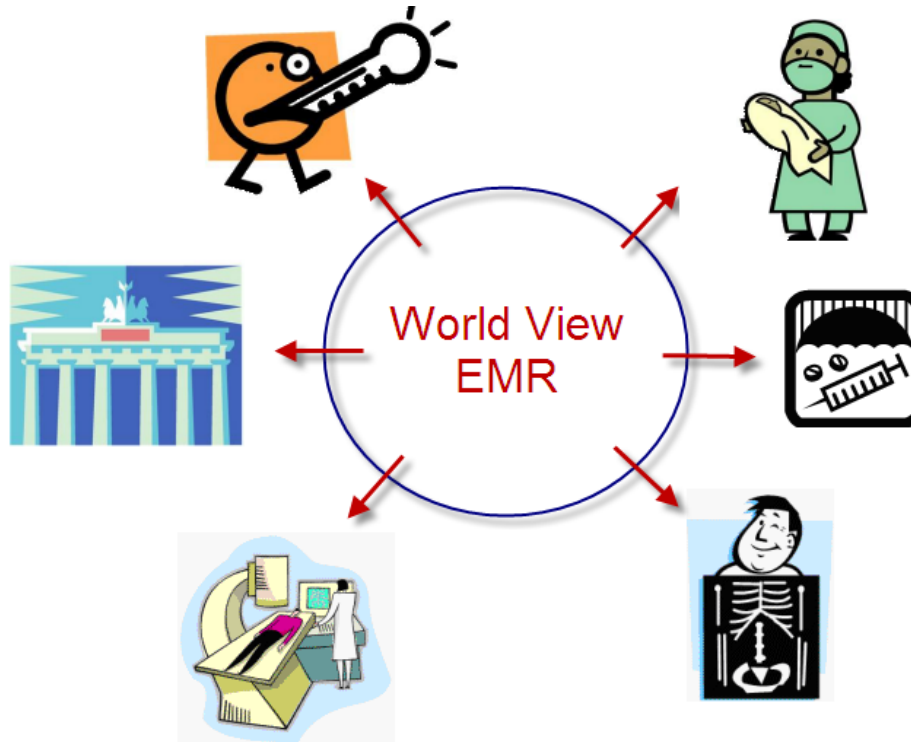
[Fig. 49] – World View

Let's take a look at different views of EMR by few entities-

5.1   Government View

Barack Obama government has devoted $20 billion to healthcare IT in the American Recovery and Reinvestment Act. In February 2009, he announced widespread adoption of electronic health record for each person in the U.S. by 2014. [86]

"Digitization of the healthcare system will be much more efficient and cost-effective, and will enable easier communication among different parts of the system, simpler manageability, and less storage compared to paper records," explained Dr. Pierce. "EMRs allow healthcare providers to send queries

electronically, which is expected to decrease the errors that are made on paper and ultimately, save lives. [87]

The 20th **Health Information and Management Systems Society (HIMSS)** annual survey of chief information officers found that 31% of the 304 participants said their number one priority is to ensure their organization has a full EMR. Within the clinical environment, 31% of participants said that at least one of their facilities already had a fully functioning EMR, which is a 9% increase on last year. A further 17% said that their primary focus would be implementing a computerized provider order entry system. [88]

Charles Christian, chair of the HIMSS board said of the 2009 survey: "The economy is affecting all sectors, healthcare IT included, but the good news is healthcare IT still continues to grow."

CIOs said financial support continues to be a barrier for healthcare IT professionals with 28% noting that lack of adequate resources raises significant issues in decision-making plans and implementing IT. [89 - 90]

As of 2005, one of the largest projects for a national EMR is by the National Health Service (NHS) in the United Kingdom. The goal of the NHS is to have 60,000,000 patients with a centralized electronic medical record by 2010. [89 – 90]

For the analysis and better healthcare standards of American society, the government views the PQRI standards. These are standards which covered entities follow to claim for the healthcare benefit which government provides. In return the government analysis these standards to find out if the physicians are performing best practices in healthcare industry. This in return reflects the quality of healthcare that is being provided to the patient.

5.2   Physicians View

Physicians view of EMR matters the most as they are the primary users for EMR. There are several benefits which a physician might see in implementing EMR solution.

- Remotely Accessing the data
- Searching for a record
- Reports and other analytical tools

- Security and Data Backup Ease

- Access to Medical Dictionary and other relevant items

- Printing records, reports etc

- Direct submission and retrieval of data from Labs

- Billing information

- Other detailed information

On the other hand physicians view might also resist the use of EMR due to following

- Expensive Implementation of System

- Resistance to change from the old procedure

- Training for the staff members

- Regular maintenance

- Dependency on the Network

Dr. Robert Jackson, an advisory board chairman for Care Entrust, checks information on his laptop at Shawnee Mission Pediatrics. Jackson says he looks forward to the day when electronic medical records will replace the thousands of paper medical records now used. [91]

[Fig. 50] – Paper Piles of Patients Data

5.3　　Patients View

Patients who are aware of the EMR system and its benefits will definitely look forward for a physician's office with EMR implemented.

- Lot of time saving for a patient
- Streamlining of the updates related to a patient.
- Automated process of lab reports and other system reports to doctor's office.
- Link to insurance company for reliability
- Use of modern techniques.
- Better healthcare

Patients might also have a resistant view of EMR implementation

- EMR implemented office might be expensive
- Security trust of electronic data

5.4　　General View

This view corresponds to many other organizations which will be effected by the use of EMR like Pathology Labs, Radiology Labs, Printing Houses, Office Supply Houses, and Health Care Insurance Providers etc.

- The labs will have an ease to maintain the data and to transfer it to a physician's office or a hospital.
- Easy to manage and less resources to manage the data, as everything will be automated.
- Ease to interact with insurance companies to clear the bills.
- Convenient for health care insurance providers to get the bills and manage the claims.

Resistance from other entities -

- It will be expensive to develop the new system for any entity whether its Pathology or Radiology.
- Heavy losses to Printing Houses and Office supply houses, who print millions of copies of record forms and other printing material used by Hospitals/ Physician's office.

6 Technology View

Technology plays a vital role in achieving the solution for managing medical records. With tremendous growth in the sphere of IT, anything now looks like a "**Cake to Bake**", and anything is achievable with good performance and reliability.

To implement the EMR system there can be a number of technologies that can be involved, some of which will be explained in the EMR Paper. But which approach or tool to be used for the EMR solution, is dependent on number of factors like Requirement, Analysis, Environment, Budget, Forecast etc

6.1 Database – [Back End]

Database plays role in storing of data and is one of a very essential entities in any successful program. There can be any type of database which follows the RDBMS concepts. Some of the databases which are normally used are:

- Oracle
- Microsoft SQL Server
- IBM DB2
- Teradata
- Sybase
- MySQL [92-93]

6.2 User Interfaces – [Front End]

Medical application involves a variety of points from which the end user interacts. Also the end users who use the application are usually physicians or clerical staffs, who are not much aware of technology. For this reason, it becomes very essential to provide a simple and interactive user interface. The UI is the point of real interaction between the physician and the data. Some of the languages which are used to provide the user interface are:

- Windows Smart Client / Windows Presentation Foundation (Microsoft)
- ASP.Net (Microsoft)
- Visual Basic (Microsoft)
- Visual C++ (Microsoft)
- Java (Sun)

Below are the few screenshots from various EMR's which uses special technologies to create user interfaces and graphical images. Earlier the UI was confined to only windows applications wherein the EMR could not get the portability. But with the advancements of technologies like Silverlight you can achieve excellent rich user interfaces which will be portable and the physician can use it over the web from anywhere. Also with the advancement of bandwidth of internet, no it's not a big time taking thing to transfer data over the net. It happens with a blink of eye.

When it comes to the use interface of an EMR a physician looks at several things which he needs before he considers the EMR to be useful. Some of the things that the physician would consider imp for an EMR user interface are as follows: [94]

- The first and foremost thing is the data entry. The physician under no circumstance wants to do the work of a secretary. He would want the user interface to be intelligent and viewable so that it gives clarity to the physician where to enter and also provides tips and hints that what should be written there. If the doctor has already written something in a particular block for some other patient then it should come as a choice to the doctor when giving diagnosis for the other patient.
- Historic data for all the tests performed on that patient. This will help tremendously for the doctor to analyze perfectly what is to be done.
- Details from other information pool which will help in analyzing the patient disease and enter the comments there and then in the EMR.
- All patients related information like allergies, previous diagnosis etc.
- User interface customization. This involves user preferences which are like which page the physician wants to view for the first time. Application color and fonts also play an important role as this is what the physician will look and deals with. Enabling shortcuts on the screens which will help the physician to enter the data very quickly.
- Portability is also very important now days. If the EMR solution is provided in a light weighted tablet PC then it will be very convenient for the physician to carry it all over the hospital. There are several divisions in a hospital and it spreads to a large distance. Also if the EMR is in a tablet pc then the physician can carry it over with him anywhere and can connect to the internet anywhere. In this way the physician is always connected to his patients or his data.
- The navigation in an EMR data entry application is very important. Although training has to be provided for any software use, the application should be user friendly enough that it speaks user words.

- • With the advancement of web application development, it's very easy to integrate the pre compiled widgets for different modules into your application. This way the application will be more stable and robust.

Below are some examples of some interactive UIs, better user interface will help the physicians and nurses in entering and analyzing the data.
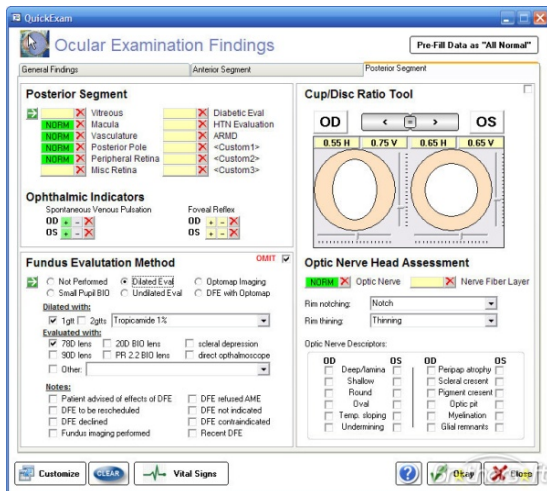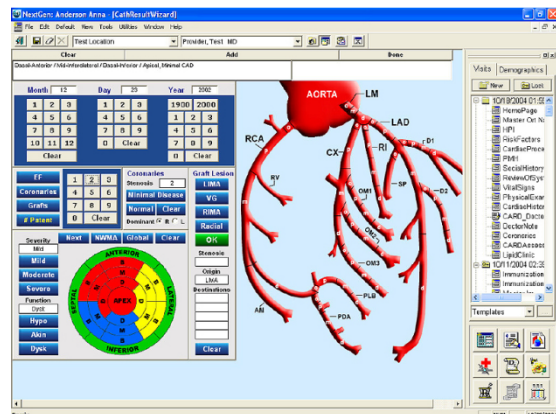

[Fig. 51] - Ophthalmology EMR
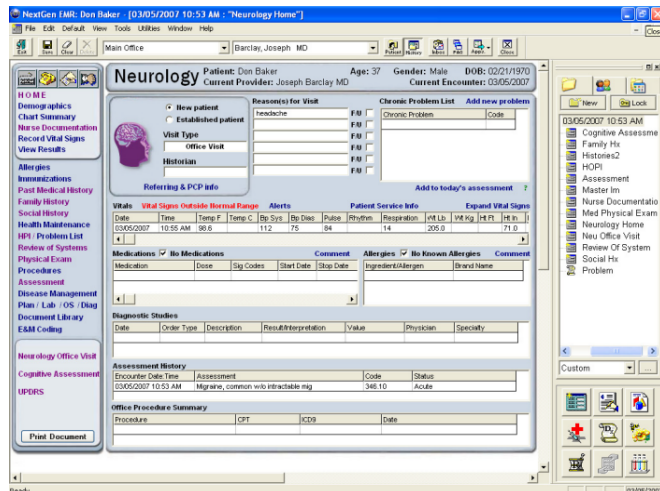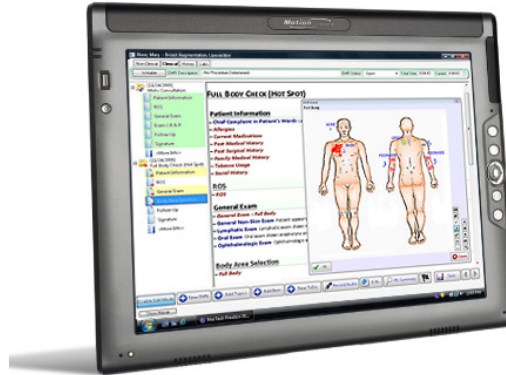

[Fig. 52] - Neurology EMR

[Fig. 53] - Cardiology EMR – Tablet UI

[Fig. 54] - Cardiology EMR – Detail Screen

[**Fig. 55**] **- Tablet EMR**   [**Fig. 56**] **- Dermatology EMR**

6.3   Reporting

Reporting is very essential to analyze complex data and extract meaningful information from it. When it comes to reporting for clinical data the complexity is even more as the data points are scattered and the data model is very complex. Some of the tools available to achieve reporting are:

A.   **Cognos**: It is very efficient reporting and analysis tools; the suite includes Framework Model (data modeling), Report Studio (Reports), and Analysis Studio (Cubes), Metric Studio etc. Reports and cubes make use of charts, graphs etc to make data easily readable and to do quick analysis and intelligent decision making. Cognos suite is a very expensive, small organization uses SSRS for reporting and analysis. The latest cognos suite available is Cognos 10

B.   **SSRS** - SQL Server Reporting Services (Microsoft)

C.   **People Soft**

D.   **SAS**

E.   **Hyperion**

F.   **Crystal Reports**

Reporting can be considered as an essence of the data that is stored in the database. Reports can be of many types in clinical data starting from the simple ones which will just fetch records like daily patient entry in a day or can be really complex like yearly report of all patients' accounts and their transactions. Depending on the requirement of the complex level of the reports, the data queries are written and models are build up. Reports can be at the EMR Program level or it can be at the level where the Datawarehouse is developed, where analysis of the data is performed. For eg. A physician can look at tall the patients he has seen for the last one week can be controlled via EMR program. This is a type of physician's view of the data. But in case

of EHR system where some analysis needs to be done with huge data by the government, then the reporting is being done on the Datawarehouse. Like government might want to audit a hospital record and analyze a particular code of conduct for PQRI etc. These Datawarehouse are developed on top of the EMR system and their input is the output of the EMR systems.

Below are samples of few reports pertaining to different areas in Healthcare.

NQF - Diabetes Measures

E & M Codes: Clinic Only
Encounter Date(s): Jan 1, 2010 through Mar 31, 2010

Location	Provider	Dilated Eye within 12 Months	Micral Strip within 12 Months	Foot Exam within 12 Months
SETMA 1	Aziz	48.1%	61.5%	61.5%
	Duncan	53.7%	37.3%	79.1%
	Groff	52.1%	51.1%	78.7%
	Henderson	53.8%	69.2%	84.6%
	Murphy	35.1%	62.8%	81.6%
	Sims	54.8%	45.2%	82.2%
	Thomas	34.6%	43.1%	74.6%
	SETMA 1 Totals:	45.0%	53.9%	76.8%
SETMA 2	Ahmed	66.8%	32.6%	97.4%
	Anthony	74.3%	84.5%	97.3%
	Anwar	79.7%	82.1%	93.5%
	Cricchio	61.2%	80.0%	75.6%
	Holly	75.0%	84.1%	88.6%
	Leifeste	69.2%	83.9%	75.8%
	Wheeler	58.0%	71.4%	91.1%
	SETMA 2 Totals:	69.0%	60.9%	91.4%
SETMA West	Curry	47.7%	54.1%	80.2%
	Delparine	54.2%	20.8%	87.5%
	Halbert	45.8%	23.4%	55.1%
	Horn	38.4%	52.9%	95.9%
	Satterwhite	59.8%	78.2%	60.9%
	Vardiman	45.2%	35.5%	74.2%
	Young	48.7%	37.2%	85.0%
	SETMA West Totals:	46.6%	43.2%	75.1%
	SETMA Totals:	57.6%	55.0%	83.8%

Apr 21, 2010 9:01:06 AM   1 of 1   NGNQ120

[Fig. 57] – **SETMA Diabetes Report Sample**

This describes the standards on which a physician needs to perform for their evaluation.
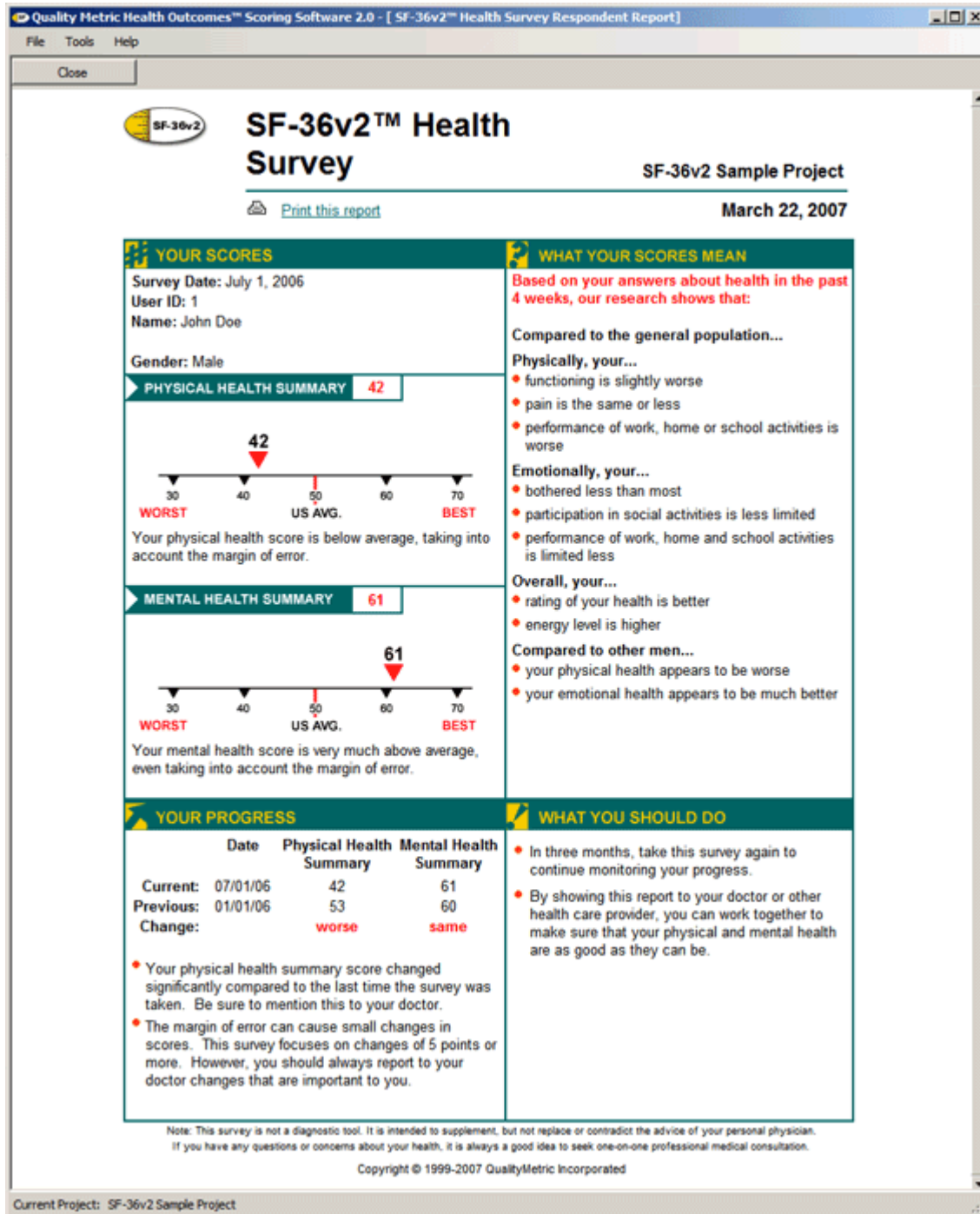
[Fig. 58] – Health Survey Report

Periodontal (Gum Disease) Risk and Disease Analysis

Prepared By:

Dr. Randy Nolf
1255 Maple Drive
Vader, WA 98025

Phone: 360.555.1234
Fax: 360.555.2589

Date Prepared: 11/16/2003

Prepared For:

Joe Thompson
Age: 64
Risk Assessment ID:
D8ED9948-57D3-41AC-A2EC-BF396A14DF02

Patient PreViser ID:
D8ED9948-57D3-41AC-A2EC-BF396A38722

Risk of Gum Disease: 2

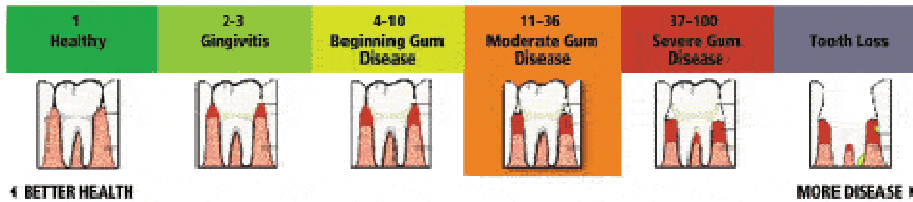◄ LESS RISK   MORE RISK ►

| 1 | 2 | 3 | 4 | 5 |

Risk predicts your future disease state. Your risk is determined by risk factors, which are distinct from the signs and symptoms of disease. Preventing disease requires treatment that reduces your risk factors. With routine dental care, tooth loss is 10 times more likely for an individual who has very high (5) risk compared to an individual who has low (2) risk. However, when risk is used to guide the selection of special treatment, tooth loss can be reduced 50% to 100%.

Disease State: 21

Generalized Moderate Periodontis

Your disease state reflects the amount of damage caused by gum disease. As the disease state worsens, treatment increases in amount, complexity and cost. Tooth loss and the failure rate of repairs are greater for individuals with higher disease state scores. Treatment can repair the damage caused by disease, but tends not to help much in preventing new disease, and may even increase the risk of new disease. Disease prevention requires treatment that reduces your risk factors. The best treatment incorporates both repair (where needed) and prevention.

Your Score: 21

| 1 Healthy | 2-3 Gingivitis | 4-10 Beginning Gum Disease | 11-36 Moderate Gum Disease | 37-100 Severe Gum Disease | Tooth Loss |

◄ BETTER HEALTH   MORE DISEASE ►

Characteristics of Health and Low Risk	Your Characteristics of Health and Low Risk	Analysis
Bleeding during exam or flossing	Bleeding during exam	Bacteria are causing an infection, which can worsen your disease state
Bone height	Moderate bone loss	Significant bone loss has occurred and additional bone loss could cause you to have a tooth extracted
Calculus in the pockets	Tartar below the gumline	Calculus is a major cause of disease state worsening
Defective restorations	A filling or crown does not fit well	This condition traps bacteria, which cause gum disease and decay
Diabetes	Not diabetic	Best possible condition
Furcations	Bone loss in a furcation	Cleaning the bacteria from these sites might not be possible leading to a worse condition
Oral hygiene	Too much bacterial plaque	Preventing new disease is extremely difficult and treatment is most likely to fail
Pocket depth	Deepest pocket is 5-7 mm	Bacteria is beyond the reach of toothbrush and floss and possibly the dentist's tools
Smoking	Smokes 10 or more cigarettes per day	Smoking this much complicates treatment and increases the likelihood of failure
Vertical bone lesions	X-rays show bone level is uneven	Usually consistent with deep pockets that worsen

[**Fig. 59**] – **Gum Disease Report**
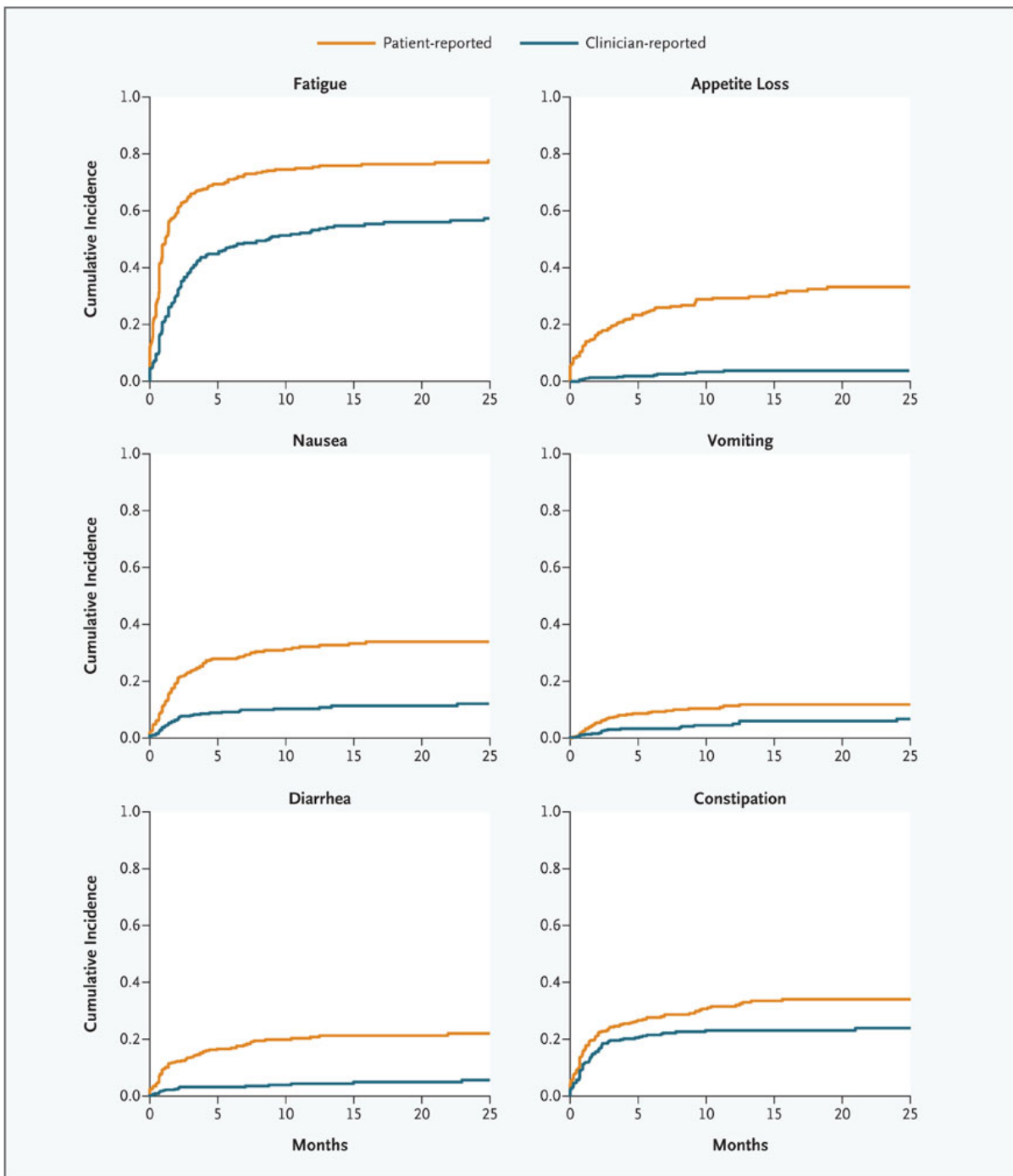
[**Fig. 60**] – **Rare Disease Report**

Neighborhood Family Doctors, PA
Remington Oaks Building 525 Oak Centre Drive San Antonio, Texas 78258 V:210.123.4567

Clinic Name: Neighboorhood Family Doctors

Address: 102 Main Street Suite 101

San Antonio, TX 78257

Phone: 210-555-1212

Patient Name: Luis Franco Gonzalez

Date of Birth: 04/14/1977

Date Collected: 04/17/2006

```
□ ==== PICCOLO - DEMO ====
04/07/06      08:56 AM
PATIENT TYPE:      MALE
PATIENT #: 45
COMPREHENSIVE METABOLIC
DISC LOT #:      5200D
OPERATOR #: 655321
DOCTOR #:  564157
SERIAL #:      0000000070
.........................
NA+  137* 228-345  mmo\L
K+   4.0* 6.6-9.1  mmo\L
tCO2  26* 28-53    mmo\L
CL-  103* 198-208  mmo\L
GLU   96  93-218   mg/dL
CA++ 9.2  9.0-20.3 mg/dL
BUN  15* 17-82     mg/dL
CRE  0.9* 1.6-5.2  mg/dL
ALP  55* 83-128    U/L
ALT  29* 90-98     U/L
AST  25  21-88     U/L
TBIL 0.9* 1.2-3.6  mg/dL
ALB  4.4  4.3-8.5  g/dL
TP   7.3* 8.4-9.1  g/dL

INST QC: OK   CHEM QC: OK
HEM 0 , LIP 1+, ICT 1 +

□
```

	Interpretation	Cutpoints* mg/dl	Cutpoints* mmol/L
Total Cholesterol (CHOL)	Desirable	< 200	< 5.17
	Borderline High	200 - 239	5.17 - 6.18
	High	≥ 240	≥ 6.20
HDL	Risk Factor	< 40	< 1.03
	Negative Risk Factor (Desirable)	≥ 60	≥ 1.55
Triglycerides (TRIG)`	Normal	< 150	< 1.70
	Borderline High	150 - 199	1.70 - 2.25
	High	200 - 499	2.26 - 5.64
	Very High	≥ 500	≥ 5.65
LDL (CALC)1	Optimal	< 100	< 2.58
	Near Optimal	100 - 129	2.58 - 3.33
	Borderline High	130 - 159	3.36 - 4.11
	High	160 - 189	4.13 - 4.88
	Very High	≥190	≥4.91
VLDL (CALC)2	Normal	< 30	
	High	≥30	
Total Chol/HDL Ratio (TC/H)3		Male	Female
	Low Risk	≤ 5	≤ 4.5
	High Risk	> 5	> 4.5

[**Fig. 61**] – **Lab Results Report**

CLINICAL REPORT: Periodontal Risk and Disease Analysis

PREPARED BY:

Dr Washington Sheffield
170 Broad St, New London Alabama 06320
Phone: 860-555-5678, Fax: 860-555-1234
Email: drs@sheffield.com
www.sheffield.com
Date Prepared: 11/02/2003

PREPARED FOR:

Demo_Joe Demo_Thompson
Age: 64
Risk Assessment ID:
6C838E96-0C07-40D9-BECF-8D2F7F4FCA11
Patient Previser ID:
2D45F8D5-5035-4215-A68B-AC098EBD6E70

Patient History

Dental Care	Irregular
Smoking History	Former Smoker
Diabetic	Not diabetic

Dental History

|	
Perio Surgery for Pockets	No
Bleeding on Probing	Yes
Furcation Involvements	Yes
Defective Subgingival Restorations	No
Vertical Bone Lesions	No
Calculus on Radiographs or Below Gingival Margin	Yes
Oral Hygiene	Acceptable

Treatments Performed

Related to Teeth

Restorations	1 Tooth

Pocket Depths

5-7 mm   < 5 mm   5-7 mm

> 7 mm   5-7 mm   5-7 mm
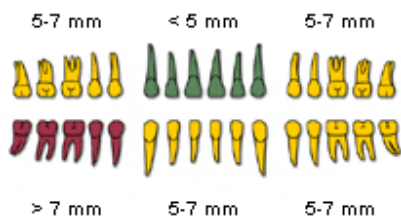
Radiographic Bone Height from CEJ

2-4 mm   < 2 mm   < 2 mm

2-4 mm   < 2 mm   2-4 mm
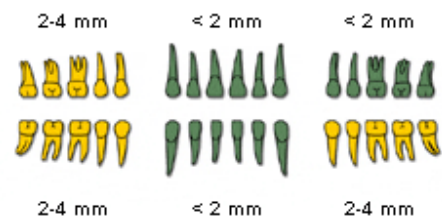
Risk Score: 4
Disease State: 59
Generalized Beginning to Severe Periodontitis

[**Fig. 62**] – **Clinical Report**

6.4 Technical Standards

There are standards which the EMR system has to follow for the information transfer or to maintain data integrity and privacy.

HL7 Messages (Health Level 7)

Health Level 7 International is a nonprofit organization which has ANSI accredited standards and is there to provide standards of interoperability which improves the delivery mechanism, optimizes the workflow and reduces ambiguity in the data transfer. It provides a framework and standards for transfer of electronic health information. It provides standards which cater the following:

- Exchange
- Integration
- Sharing
- Retrieval

HL7 has the member list which covers EMR/EHR and other health care related applications, and they covers more than 90% of the total market. HL7 refers to Level Seven of International Organization for standardization seven layer communication models for open systems interconnections. [95-96]

HL7 messages importance:
HL7 messages are very important part of communication between these diverse systems of healthcare. It behaves like an interface where all the system speaks and understands the same language. Healthcare providers have many systems like patient tracking, labs, radiology, finance etc and all these can be present inside one facility or can be separate entities. HL7 message system specifies certain guidelines and structure and methodologies by which these messages travel between different systems, for the information to be transferred in a consistent and uniform pattern. [95-96]

The figure shows how a database interacts with different systems and how there is a common language of understanding. Some of the systems are like LIS (Lab information system), HIS (Hospital Information system), PACS (Picture archive and communication for radiology) etc. ORU, ORM etc are message types.
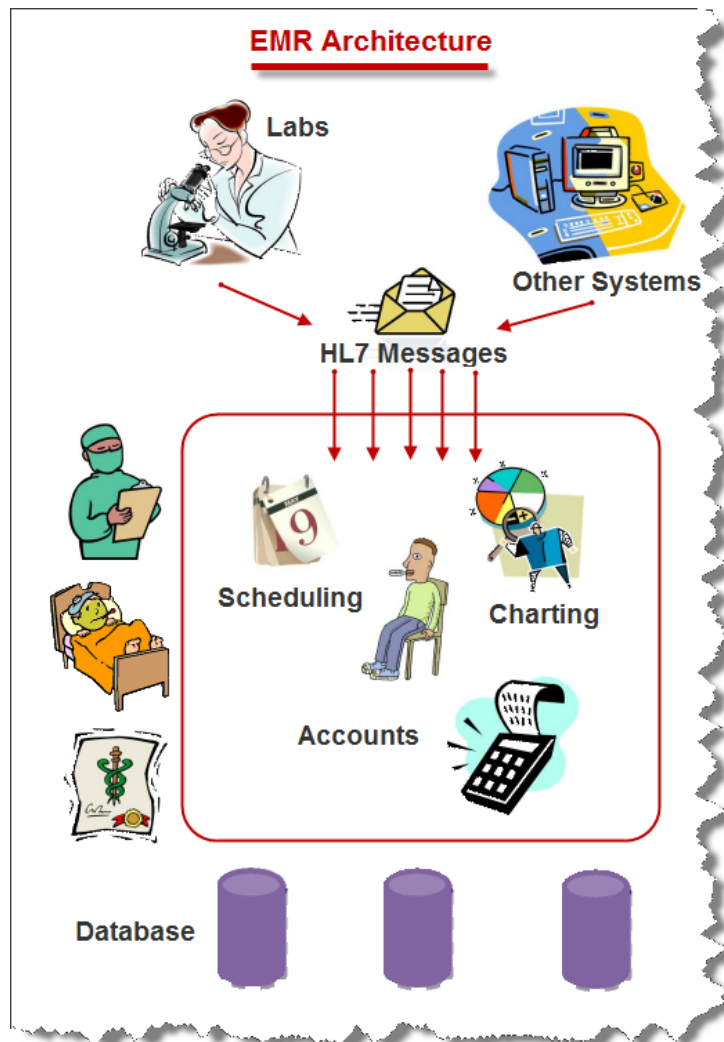
[Fig. 63] – HL7 Interaction

HL7 message standards:

HL7 RIM (Conceptual Standards): This ANSI approved model is the cornerstone of HL7 3 process. It is a pictorial representation of HL7 clinical data and identifies the lifecycle that a message or group of messages carries. This is a domain which is shared amongst all the domains and all the domains create their messages from this RIM.

HL7 CDA (Document Standards): Provides standards for exchange of Document notes like Discharge notes, summary and progress notes. Here the CDA uses the RIM and XML and some codes of libraries and prepares the documents that are easily parsed and processed electronically and also they are human readable.

HL7 CCOW (Application Standards – Clinical Concept Object Workgroup): It's a standard protocol that allows user to experience integrated computer user sessions on desktop.

HL7 2.X and 3.0 (Messaging Standards): One of the most recognized messaging standard across what world. The messages exchanges information in many areas like Patient demographics, insurance and finance, medical documentation etc. [95-96]

HL7 message Sample:

```
MSH|^~\&|GHH LAB|ELAB-3|GHH OE|BLDG4|200202150930||ORU^R01|CNTRL-3456|P|2.4<cr>
PID|||555-44-4444||EVERYWOMAN^EVE^E^^^^L|JONES|19620320|F|||153 FERNWOOD DR.^
^STATESVILLE^OH^35292||(206)3345232|(206)752-121||||AC555444444||67-A4335^OH^20030520<cr>
OBR|1|845439^GHH OE|1045813^GHH LAB|15545^GLUCOSE|||200202150730|||||||||
555-55-5555^PRIMARY^PATRICIA P^^^^MD^^|||||||||F||||||444-44-4444^HIPPOCRATES^HOWARD H^^^^MD<cr>
OBX|1|SN|1554-5^GLUCOSE^POST 12H CFST:MCNC:PT:SER/PLAS:QN||^182|mg/dl|70_105|H|||F<cr>
```

The Hl7 message is divided into sequence of segments specifies something. Like in above example the MSH division who sent it, where it's going and what does it contain. The PID has the demographic information of the patient. The OBR segment is the observation as it was originally ordered and the OBX is the result of the observation. [97]

ASC X12

Chartered by American National Standards Institute developed electronic data interchange (EDI) standards and other related documents. Also called as ANSI ASC X12 and was formed in 1979   . It's a standards committee under ANSI (American National Standards Institute).X12 delivers dictionary of data elements, data segments, messaging, business transactions etc. [98]

## *DICOM (Digital Imaging and Communication in Medicine)*

It basically refers to transferring and storing images. This standard was created by NEMA (National Electrical Manufacturers Association). It deals with images like CT scan, Ultra Sound, and MRI etc. It's a very important standard as Medical Science nowadays depends on a lot of Imaging of various body organs and diagnosing the problem. With technical advancements in imaging and medical science, very clear 3D images of body organs can be captured which can be just like the real organ and helps tremendously in diagnosis from anywhere in the world. [99 – 102]

The DICOM file consists of few segments. The header segment contains the information about the patient, its diagnosis, scan type etc. The other segments contain the Image data. This data can represent simple images to complex 3D images. The beauty of DICOM is that the image data can be compressed. This is very important in case of transmitting large data. DICOM is being used by Hospitals, Imaging Centers, Clinics and other specialists like Radiology, Cardiology, Radiotherapy, Pathology, Neurology, Dentistry, Surgery etc. DICOM works hand in hand with HL7 industry standards.

Small distribution pattern of DICOM is described below
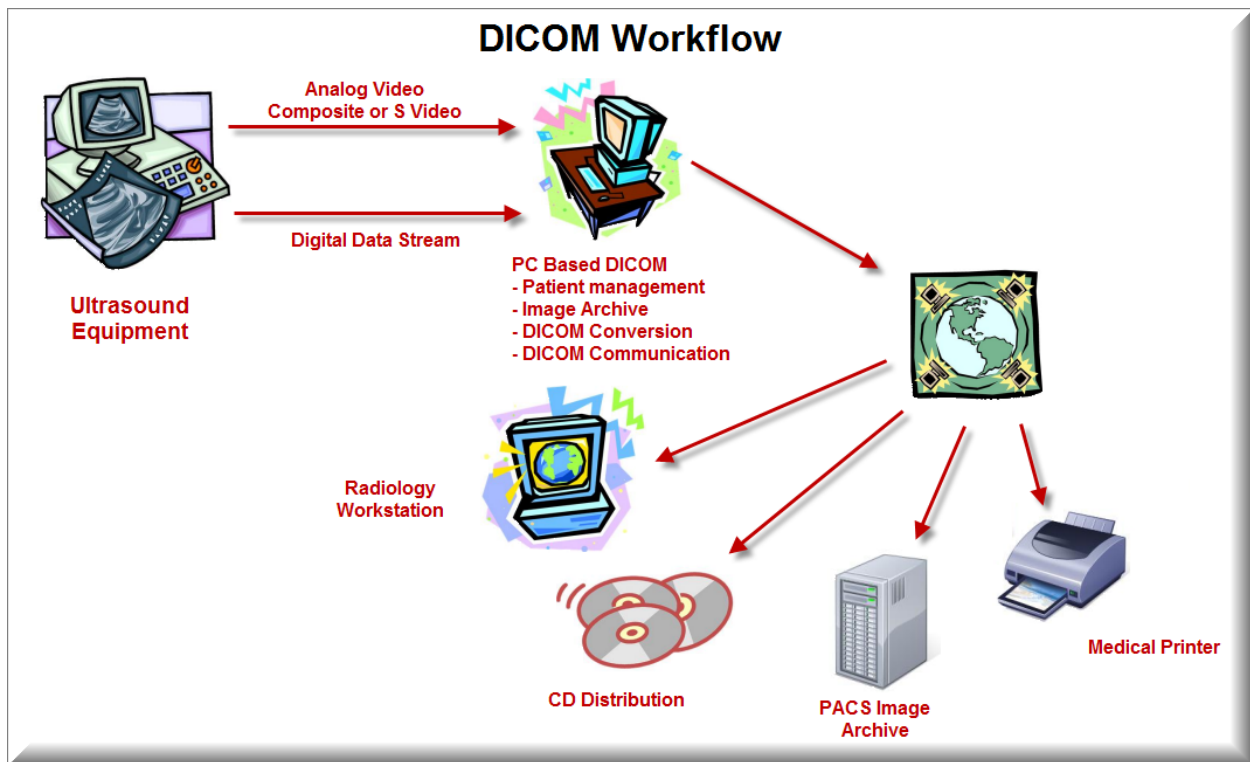
[Fig. 64] - DICOM
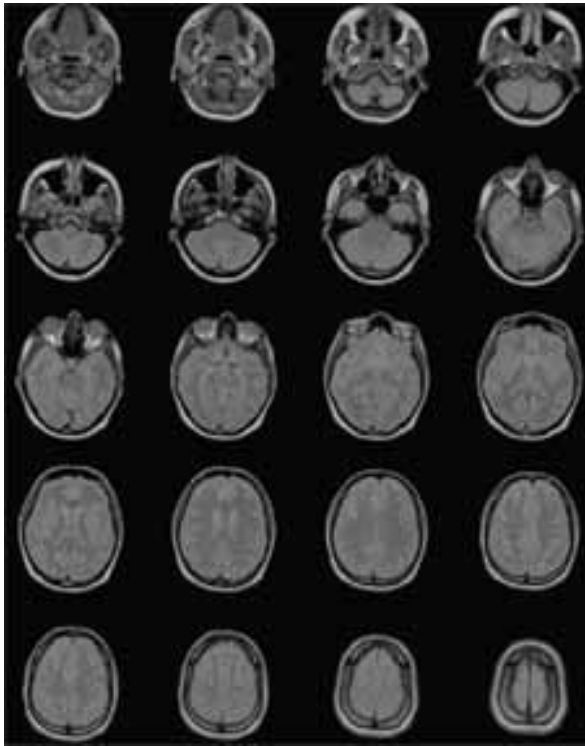
[Fig. 65] – Matlab Image of DICOM

Continuity of Care Record (CCR)

This is a standard developed by ASTM International, The Massachusetts Society, Healthcare Information Management Systems Society, American Academy of Family Physicians and American Academy of Pediatrics.

This is a standard which contains the recent and relevant patients care information.
It contains various sections where information is embedded like patient's demographic section, diagnosis section, administrative section, insurance section etc. This entire message is defined in the formal of XML which is universally accepted language and also understood by all the systems.
Special care needs to be taken for security of this CCR data as only authorized persons with access should be able to view a particular set of information from the CCR data. [103 – 106]

7 Datawarehouse Concepts and Implementation in Healthcare Industry

7.1 What is Datawarehouse?

McFadden defines Data Warehousing as a subject-oriented, integrated, time-variant, nonvolatile collection of data in support of management decision-making.

1. Subject-Oriented: Organization of data in a warehouse is around the key subjects (or high-level entities) of the enterprise. For instance, patients, students and products.

2. Integrated: The data is assumed to be using consistent naming conventions, formats, encoding structures, and related characteristics for sharing and usability.

3. Time variant: Data contain a time dimension so that they can be used for historical purposes

4. Nonvolatile: Data are refreshed from operational data, and cannot be updated by users.

Considering the above key terms data warehousing could be defined as the process by which an organization extract meaningful information from historical data. Thus data warehouse is a planned data store. As an organization can largely be divided in different departments, each department can have their own data store which is referred to as a data mart all these data marts for different departments when joined together will form a data warehouse for that organization. [107-108]

7.2 Transactional Sources

In a hospital or doctor's clinic there are many patients coming and going. Everyday there can be hundreds of new patients and also same patient can come with different health problems. A patient can undergo many tests and thus the information about a patient can change many times. All the preliminary information and changes in the information is filled in manually by clerk or nurse. And this information is stored in database called as Transactional database. The transactional database is also called as OLTP databases (Online Transaction Processing).

The major source of data in any Datawarehouse is transactional Database. Transactional sources are designed for fast data inserts and thus faster updates. The transactional databases are much faster in inserts and updates because they have much normalized table structure and for the same reason it is very difficult to report on the transactional data as it reduces the performance. As the reporting database require

much de normalized data for faster access. Other then this as transactional data is entered by the clerks at front desk there can be various human errors in the data and this makes the data not so suitable for the querying

Datawarehouse has read only data which means that it contains the historical data which is not meant to be changed. Although one can change it anytime and it's very much possible but the main purpose of data warehouse is to carry purest form of data. Also in a organization like a hospital there may be a scenario that there are different applications for different divisions like Accounting application for maintaining hospital finances, HR application for maintaining hospital HR resources, Radiology and Labs applications which store patient related tests data, Patients Information Applications which stores and manages all the primary patients information. And now in this scenario all the applications might use different databases and there has to be a storage place which can consolidate all the information from different databases and store them at one place or manage relationships amongst them. Hence in this place a data warehouse creation plays a vital role. [109]

7.3   ETL – Extraction Transformation Loading

ETL stands for extraction, transformation and loading. ETL is a process of extracting data from various operational or archive systems, then transforming the data which may involve cleaning of inconsistent or bad data, filtering, validating the data and applying various business rules to the data and then loading the data into a data warehouse

For example, Sales data can be extracted on a daily basis; financial data usually makes sense at the closing of every month. Similarly the data from California based company and New York based company cannot be extracted at the same time due to the time difference between two zones on daily basis can however, daily extracts might not be suitable for financial data that requires a month-end reconciliation process.

Extraction

Extraction is the process of obtaining data from a defined source. The extraction records could be retrieved from a single source or multiple sources.
These steps include extraction of the data from various places. As an organization can have several databases and there can be different ways and places where the data are stored, discovering all the different sources is important.

The data comes in the source databases through several places. Different sources of data use different formats of data, making this data heterogeneous in nature. From an EMR perspective the majority of data is entered into the system by administrators, IT staff, and nurses. Mostly the data in a hospital is entered by the hospital or clinic clerks or nurses. With the finding of the data sources it's also important to know beforehand what kind of data the source has. This is important so that we can plan our transformation accordingly which might require time depending on the kind of data. Also as the availability of the data can be different depending on the difference in physical location of the facility and also depending on the departments, it's important to note all these aspects of data so that we can also plan our staging database and loading.

Below are the points to be kept in mind while looking at the extraction process

All data sources should be reliable - What kind of end results do we want that is the question which you require to ask before looking at the sources?   How much historical data will you need, how much and how often and what data is required, these are very important questions to answer to really determine the different data sources in the extraction process.

The data should be available on time- Timely extracting of data is important. The basis of creation of data warehouse is to provide timely information to the end users. All the data sources must be ready and should have all the information required to be extracted otherwise the end results will be incomplete and can be incorrect also.

The data which is being extracted should be complete - Incomplete data will result in incomplete and wrong results for the users which can lead to many other problems like wrong decision making. The data should be in standard format and in synchronization with the business needs. [110]
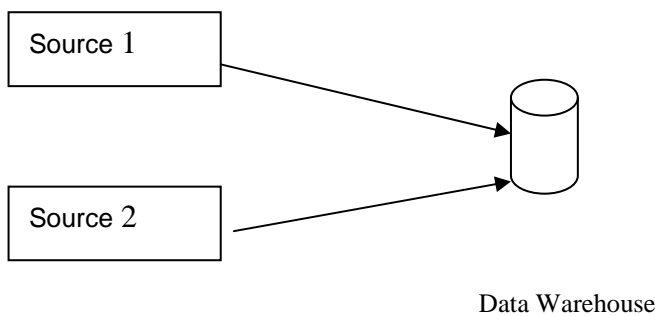
Transformation

Transformation is the most important part of the whole ETL process. It requires lot of planning and needs the most amount of time. How much transformation is required depends on the kind of data we are dealing with and the kind of result we want. There are rules which are required to be defined for the transformation of data. These rules depend on the way business users wants to see the resultant data. The data is selected and rejected on the basis of these rules and the selected data is transformed and loaded into the staging area or to the final databases depending upon the process. The way rules are defined and the way rejection of the rows takes place depends on the tool which is used for the ETL.

There are many good tools available in the market like Cognos Data manager, Microsoft SSIS, Informatica etc. All the new tools are very flexible and show the process graphically and make the life of programmer much easy.
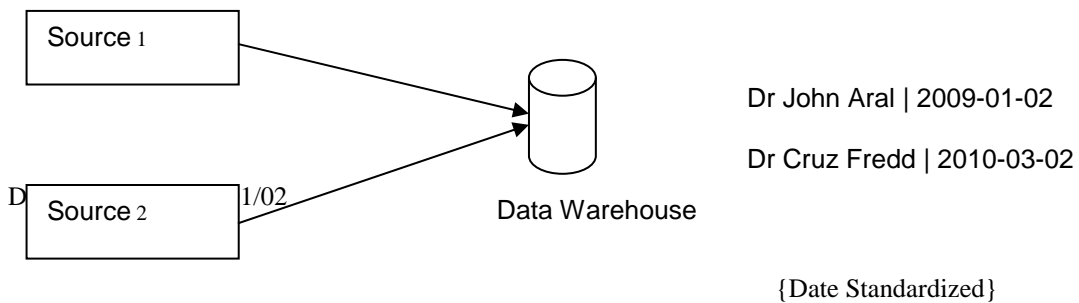
Below are various kinds of transformation which can be required in the process -.

Integrating the data- This is the main part of transformation step i.e. to collect all the data from various databases and various locations and integrate them all to do analysis on overall integrated data

```
┌──────────┐
│ Source 1 │────────┐
└──────────┘         ╲
                      ╲
                       ▭ (Data Warehouse)
┌──────────┐         ╱
│ Source 2 │────────┘
└──────────┘
```

Data Warehouse

[Fig. 66 – Integrating Data]

Standardization of Data- As the data come from so many sources, the format of data may be different from one database to another. That is why it is important to have the standards set for all the data. And the transformation of the incoming data should take place accordingly, to avoid any inconsistency

```
┌──────────┐
│ Source 1 │────────┐
└──────────┘         ╲
                      ╲
D                      ▭ (Data Warehouse)      Dr John Aral | 2009-01-02
┌──────────┐1/02     ╱
│ Source 2 │────────┘                          Dr Cruz Fredd | 2010-03-02
└──────────┘
                     Data Warehouse

                                               {Date Standardized}
```

Dr Cruz Fredd | Mar-02-10

[Fig. 67 - Standardization]

Data quality Check and thus transforming the incorrect data- Data coming from various sources should be checked before it comes and if there is any mistake, it should be corrected by transformation process.

Example-

Before -

Eg ('   Dr John, Wiley | ')

After - white space and extra characters removed

Eg ('Dr John Wiley')

Data Relevance and filtering the unwanted data- There are times when the data is completely unwanted. For example the data coming from one of the source is 20 years old and end user doesn't want to store such old data in Datawarehouse. For this reason the old data should be filtered out.

Example- end user doesn't want to store data from Ophthalmology department

Department <> ('ophthalmology')

Standardization for abbreviations – For abbreviations in any fields standards should be used

Example States should be specified by two letters only. Like NY, NJ, WA etc

Data type Conversions- It is possible at times where the same field in two different data sources can have different data types.

For example the department number in one data source can be CHAR and in other it can be NUMERIC. When we integrate this kind of data there should be consistency.

Example- VARCHAR (Admission Date)

Normalization/ Denormalization- There can be a case where a table can have many columns causing difficulties in understanding the data or there can be tables which are normalized to a very great extent. In below example there is a need to normalize data which can be done in transformation.

Example-

Before Normalization

Appointment	Patient Name	Appointment Type	Patient DoB	Patient Address 1	Provider Name	Provider Specialty
2010-12-01	John Doe	Active	1970-11-10	12 Wicker St	Dr John Wiley	Cardiac Specialist

After Normalization

Appointment	Patient Key	Appointment Type	Provider Key
2010-12-01	PAT999202	Active	PRV12333

Creating new Fields, derived Attributes- New fields, or derived fields can be required in a Datawarehouse. For example the Code for a Nursing department is HA and description is nursing. We might want to show the column as 'HA-Nursing'.

Example- Full Name=CONCAT (First name, Last Name)

Calculations- There are times when we use one calculation many times and at many places. It might be a good idea to have that calculation as fields in the database.

Example- Calculating weekly hrs worked by employee, which is the total number of hours worked everyday multiplied by number of days worked.

Weekly Hrs= HrsEveryDay * DaysWorked

Aggregation-Not all the time do we require the detailed data, when ever required the data should be aggregated in the manner required and then loaded.

Example- AVG (Value), SUM (Value)

Completeness check - This may be the last step of transformation where we want to check if all the data extracted from different sources is complete. Incomplete data leads to wrong analysis.

Example Check if the sum of values is reasonable, check if the entire date range is present. [111]

Staging Area

Before the data is loaded into the target data base by ETL process, the data is usually brought to the Staging Area. The data in the staging area is copied from the various sources. The data in a warehouse comes from various places it is important to get all the data at correct time first. Due to the timing reason all the data is collected in the staging area. Which acts as the temporary storage place. The timing of extraction depends on the data processing, business cycles, geographical factors etc. [112]

Loading

The important part of the Loading stage of ETL is the duration it takes. It's important that the loading of the data is quick enough so that all the data is available in the data warehouse before the business users are ready to query the database or well before the start of a business day.

The main points to be considered during loading are-

Timely Loading- It's important to get the correct information at the correct time. Timely loading and availability of data is important. If the user needs to look at the data in the form of reports or cubes then all the data should be available in the database before the time.

Interference - None of the other process, should interfere in the loading process. In all the organization there are many process which runs at night. While loading the data in to the Datawarehouse one should contact all the departments or the DBA so that none of the other jobs interfere with loading.

Availability- The server and resources should be up and available to loading process. All the series of jobs which should run before loading the warehouse should complete before the loading process starts.

Logging – Usually Logging is important to trouble shoot the processes and to know if everything has run without problems. If there is not enough time to load the data timely, one can stop the logging of some of the process. Logging takes additional time which we can reduce, by not logging. There are different levels of logging available. Not all the processes require detailed logging. So by doing brief logging or stopping logging altogether for a process, can make the process faster and reduce the space and time for logging helping in timely loading of the data.

Index creation - These are activities that optimize retrieval of data and are usually performed as the last step of ETL. Both of these processes are important and costly. It should be handled appropriately and wisely. [113]
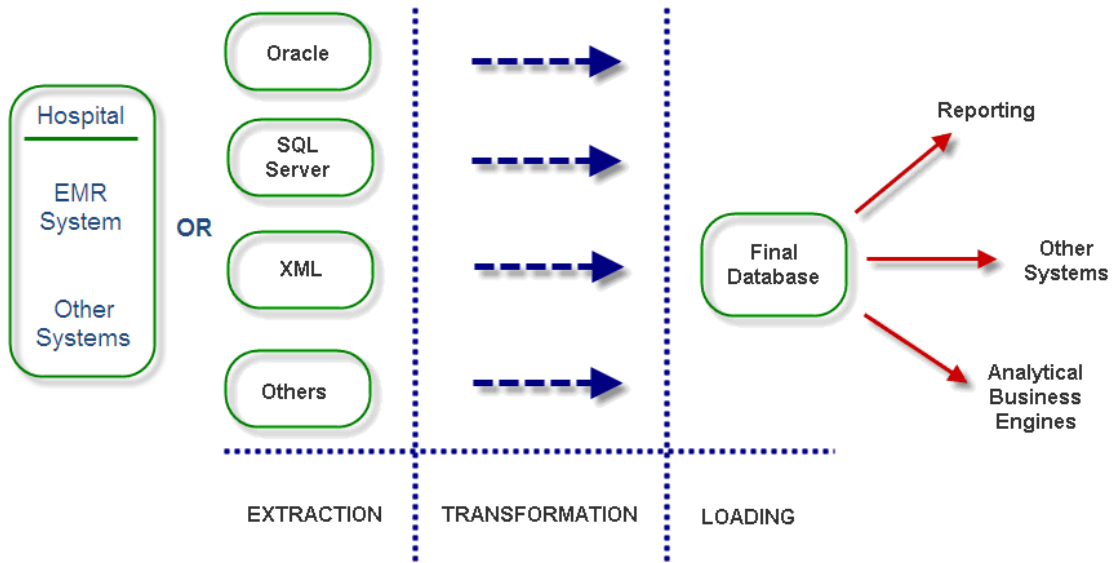
[**Fig. 68**] – **ETL Process Explanation**

Types of Loading-

1. **Full Load-** Usually when you are loading the data warehouse for the first time, after testing, from staging area, is called full load.

2. **Incremental load.** - After the full load, there are changes in the database every day. To bring those changes in the data warehouse you load only the changed data to warehouse as you already have the other data. So the loading of difference between target and source data on regular basis is called incremental load. Usually a date time field, depending on the business is used to choose the data from the target to load.

3. **Refresh load-** There are times when the data warehouse data in table is completely deleted and reloaded and this type of load is called refresh load. This is usually done when the data warehouse table is not required to be updated too frequently and also when the volume of data is not much so that deleting and loading doesn't take much time.
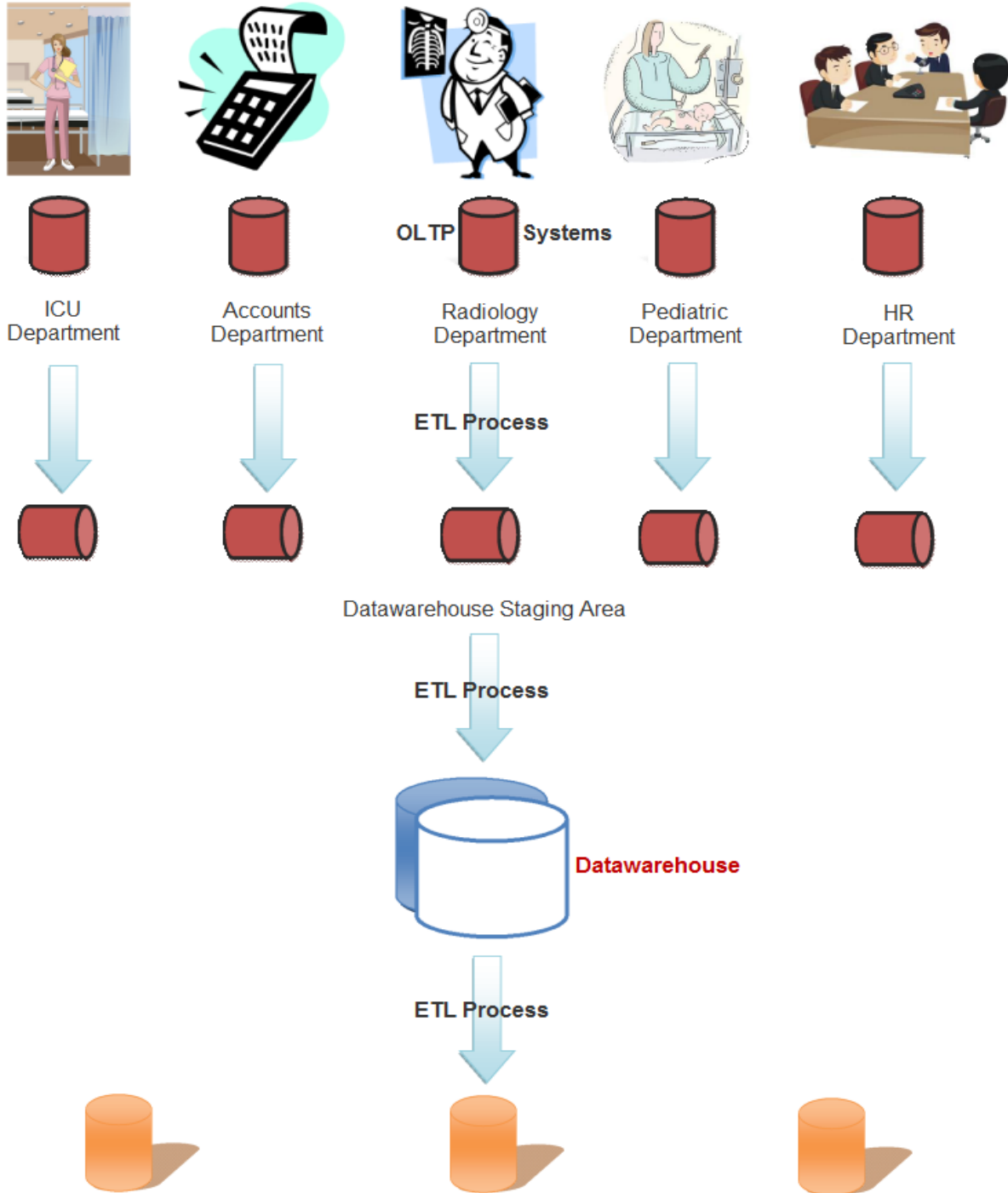
[Fig. 69] – Datawarehouse Process

7.4   Data warehouse Schemas

Before talking about the schemas lets understand the facts and dimension tables which creates the different schemas.

Fact Table- This table contains all quantitative information. They are also called Measures. The data in fact tables are numeric and mostly additive. Facts contain the foreign key to the dimension table and it maps each row of data in the fact table to its related dimensions.

Dimension Table- Dimension tables usually describes the facts. For example number 100 doesn't mean anything in itself but 100% profit; number of products sold is 100, value of the blood pressure can be 100 makes some sense. So fact is 100 and 'what' defines the fact is called dimension. Dimension table has the descriptive data for an organization. These tables are usually small tables and data in these tables are usually descriptive.

Facts are usually reference tables and dimensions are referenced by facts. Dimension data describes a single aspect of a business (such as products it sells), that gives context to the factual data (such as how much of each product was sold in a day, week month or year). Facts are connected to the dimensions; the way they are connected depends on the kind of schema.

Slowly changing dimensions

The operational dimension data is usually static. But as data in Datawarehouse can have 5-10 years of data, the dimension can change over years though slowly. That is why these dimensions are called slowly changing dimensions. Though tracking or not tracking of the changes of dimension depends on the business needs. Thus the term slowly changing dimension refers to the tracking of changes in dimension by time.

There are usually 2 types of dimensions-

Type One dimension- Overwrite the old record

There are dimension which change over the time but business doesn't need to keep the history. This usually means that if a data row changes for one of the dimension, we can just overwrite that row. Here we don't need to keep the track of the changes. No record of history is required. There can be reasons

why an organization may not want to keep the record, the previous record may be incorrect or may be the business considers the changes to be irrelevant.

For example in the below example Smith Jones changes his marital status from not married to married and so because that information is irrelevant or not so important, there is no need to maintain the history of this kind of record , so in that case the record will be overwritten.

BEFORE UPDATE

Provider_id	Name	Location	Marital Status	…….
32143	Smith Jones	Clifton	NOT MARRIED	

AFTER UPDATE

Provider_id	Name	Location	Marital Status	…….
32143	Smith Jones	Clifton	Married	

Type Two Dimension- Create a new record for change

These are the dimensions where we need to keep the old records or history. The way to track the history is by using surrogate key so whenever there is a change, a new surrogate key is created, for that change, with a new row for the record. When the change takes place usually an effective change start and end date is used to track the change. Because there are changes in the same person's record there can be multiple rows with the same primary key but all the records will have unique surrogate keys.

For example a provider moves from Rochester to NYC, so now from the date of moving the patients he sees will be reported under the changed city which will be NYC, but all the prior patients he has seen needs to be tracked under Rochester.

So now the new row should be added to the Provider table which has a new surrogate key. So the old patient who was seen in Rochester will still point to the preexisting dimension rows but the new ones will be pointed to the new dimensional record.

So whenever the track is detected the existing current row should have an end date so that the data represents that the record is no longer the current record and the new record has end date as null meaning that it is the current record.

For example there is a change in record when a Doctor Andrew Harbour changes his location from Rochester to NYC. To maintain history we create a new record the Provider ID for that record would be the same which means the key is no longer unique. So to create the key unique we combine provider id and Location.

Next time Andrew Harbour in promoted from Junior Doc to senior doctor. Again to track the record a new row is create and again key is no longer unique, so to make it unique we combine provider id and Location and specialty.

Surrogate key	Provider ID	Name	Location	Position	Specialty
1	21221	Andrew	ROC	Junior Doctor	Cardiology
*2	21221	Andrew	NYC	Junior Doctor	Cardiology
**3	21221	Andrew	NYC	Senior Doctor	Cardiology
***4	21221	Andrew	NYC	Senior Doctor	Surgeon

*   Provider ID+ Location

**   Provider ID+ Location+ Position

*** Provider ID+ Location+ Position+ Specialty

Thus with different changes in the Andrew records the key keeps on becoming long which is very inefficient and this long key will act as reference in the fact table. There can be many dimension tables and there can be changes in almost all the dimension table, they will all have such long keys and will have reference in the fact table. This situation becomes very inefficient in querying any kind of data.

So to maintain such slowly changing dimensions and preserve the history there should be a solution which tracks the changes in an efficient manner. And the solution to it is a Surrogate key. [114-115]

Surrogate Key-

Thus surrogate keys are used to track the slowly changing dimensions. Thus they maintain the uniqueness of the record. They are numeric keys, they are meaningless, assigned internally and are automatically created.

So to solve our problem we will add one more column of Surrogate key to our table and now look at the record below. With the help of surrogate key, the record remains unique and the key is also very efficient and small. [116-117]

BEFORE UPDATE

Surrogate key	Provider ID	Name	Location	Position	Specialty
1	21221	Andrew	ROC	Junior Doctor	Cardiology

AFTER UPDATE

1. When Dr Andrew Moves to NYC

Surrogate key	Provider ID	Name	Location	Position	Specialty
1	21221	Andrew	ROC	Junior Doctor	Cardiology
2	21221	Andrew	NYC	Junior Doctor	Cardiology

2. When Dr Andrew Position Changes from Junior Dr to Senior Dr

Surrogate key	Provider ID	Name	Location	Position	Specialty
1	21221	Andrew	ROC	Junior Doctor	Cardiology
2	21221	Andrew	NYC	Junior Doctor	Cardiology
3	21221	Andrew	NYC	Senior Doctor	Cardiology

3. When Dr Andrew's Specialty Changes

Surrogate key	Provider ID	Name	Location	Position	Specialty
1	21221	Andrew	ROC	Junior Doctor	Cardiology
2	21221	Andrew	NYC	Junior Doctor	Cardiology
3	21221	Andrew	NYC	Senior Doctor	Cardiology
4	21221	Andrew	NYC	Senior Doctor	Cardiac Surgeon

III. Type Three Dimension-(update the current record and keep the history in the same record.)

In type two dimensions you can preserver as much history you want but in type 3 the preservation of history is restricted due to its approach.

In case of type three dimension a new column is created for every change. If there are many changes in different dimensions, many times, this is not the best approach as the table will become too big to maintain. So, type three dimensions are very rarely used.

After understanding the concept of facts and dimensions, let's look at the different schemas they create. There are mainly two types of schemas, Star Schema and Snowflake Schema in the perfect word. These schemas are different based on the way the fact tables and the dimension tables are connected together. There are times in the practical world that an absolute star schema or snowflake may not be possible. Also it so happens many times that over the time many of the new tables are added to original schema and they might not fit in the current structure of schemas and so this may lead to a mixture of the schemas called as hybrid schemas. Let's now discuss the different schemas.

Star Schema

It is a denormalized schema. The name star schema is given because the schema actually looks l like star in shape. The star shape comes from the way the facts and dimensions are joined together. Usually there is one central table which is fact table and the many dimension tables surrounding the fact table, giving rise to a star like structure. To join the dimensions and facts together, dimension tables have primary key and the fact tables have the corresponding foreign keys.

Star Schema has fewer tables and the dimensions are connected directly to the facts. That's gives rise to a structure which has very few joins and so the query against this kind schema gives faster results as compared to any other schema. [118-121]
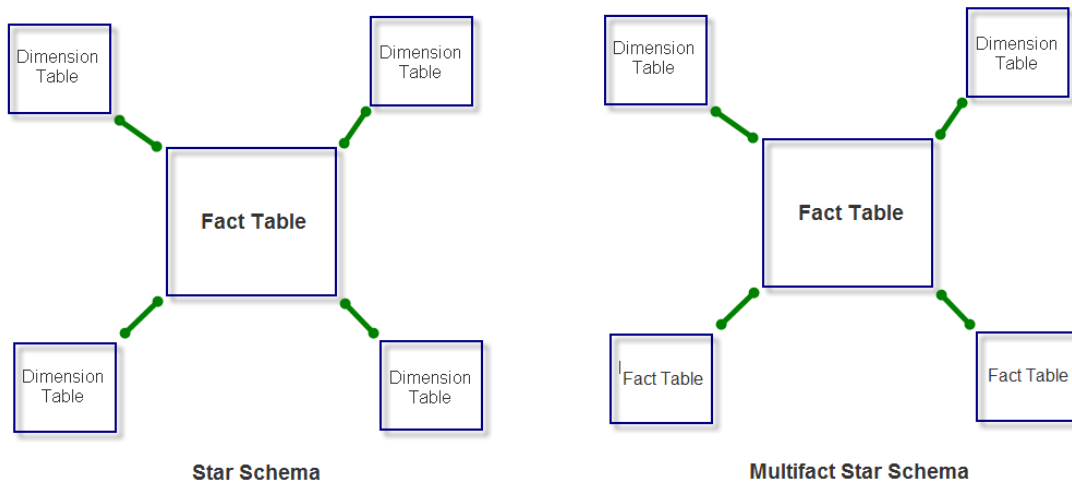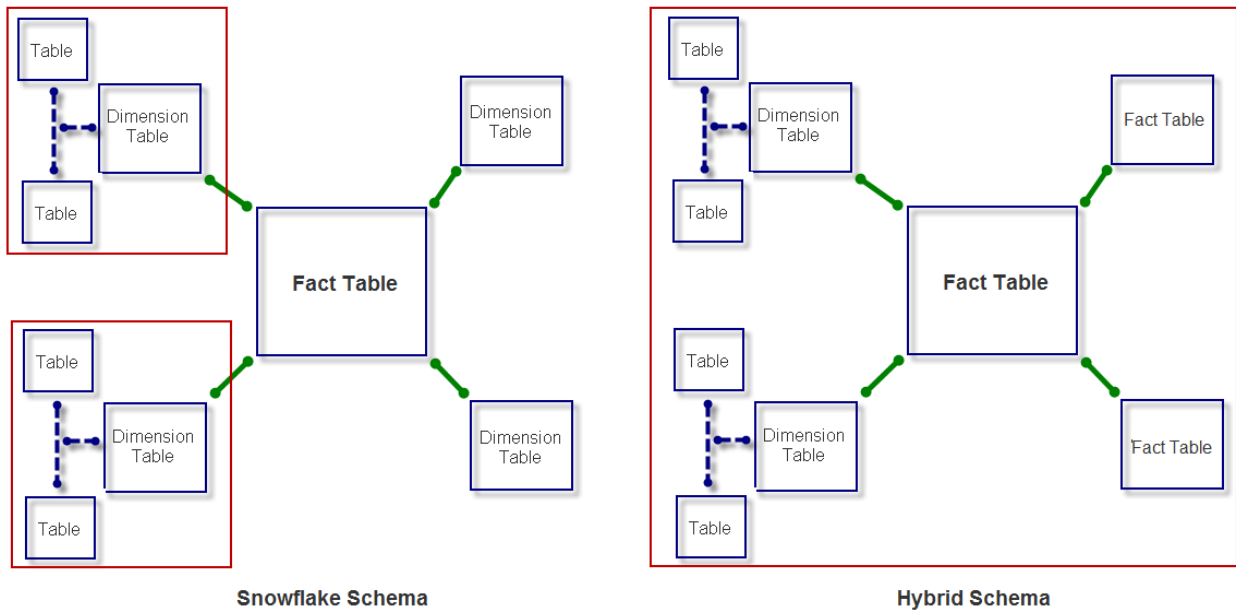

[Fig. 70] – Star & Multifact Star Schema

Star schema is one of the simplest of the Datawarehouse schemas. Star schema in a Datawarehouse is build up mostly for querying the data and not for transactions.

Multifact Star Schema- It's not necessary that in every scenario there will be only one fact table. The number of facts and dimension tables depends on the business needs and kind of data and the results which end user wants to see. There are times when there are multiple facts and dimension tables which are joined to one fact table forming the Multifact star schema. The diagram above explains the schema.

Snowflakes Schema

Snowflake is a normalized star schema. The facts and dimension tables in this type of schema are joint in such way that it looks like a snowflake in structure and hence called snowflake schema. It is almost similar to star schema with the difference that the Dimension tables are further normalized into group of tables so as to remove data redundancy.

The snowflake schema improves query performance due to less number of duplicate records and hence less disk storage requirements. The snowflake schema requires additional maintenance because it has more lookup tables. Also as the dimension tables are normalized further, for accessing data the query will hit more tables and form many joins which is not the case in star schema, making it slower then star schema [122]

[Fig. 71] – Snowflake & Hybrid Schema

Hybrid Schema

The above schemas- Snowflake, Star Schema, and multi fact star schema can be combined together and will be called as Hybrid Schema. Depending on the data and usage the facts and dimensions can be modeled in any way. [121]

7.5   Datawarehouse Process

To implement a Datawarehouse at any place needs a full project plan and a lot of understanding of the business domain may it be Medical, Finance or Manufacturing. The designing phase of a Datawarehouse is the most critical one and it's like a block on which the whole house is build.

The concept of Datawarehouse states that it has the most pristine data without any data redundancy. And to achieve it involves a lot of planning and execution. If there is any defect in its planning then the Datawarehouse will result in redundant data and hence will directly effect in performance and the whole purpose will be defeated.

There are many steps which should be considered before building a Datawarehouse. From start to end there are many standards and steps that should be followed in order to generate a full Datawarehouse and to achieve maximum out of it. Datawarehouse is an iterative process and all the requirements cannot be achieved at once. [123-126]

Process Lifecycle

Step I - Questions:
The first step involves identifying the stakeholders and Question and Answers that should be asked from them. By the end of this phase the requirement should be crystal clear to the Datawarehouse development team. Formation of disaster recovery plan should also be in action at the end of this phase which will guide through the data backup and necessary processes in case of data disasters. The common questions would be

1.   What type of reports/ analysis the hospital requires
2.   Which is the EMR system they currency have.
3.   Which systems will provide the data to the Datawarehouse
4.   Which systems interact with each other?
5.   What is the expected time of completion?
6.   Budget for the whole process.
7.   Who will use the reports and the underlying data from the Datawarehouse i.e. what will be the user base for the Datawarehouse.
8.   Who can explain the current process in the facility
9.   What will be the hardware support for the Datawarehouse

10. What should be the training pattern

11. What is the Privacy and Security in the facility

12. What all HIPAA rules currently are used by the facility

Step II – Resources

Allocating correct resources is yet another important task. There are many persons involved in a Datawarehouse process. There should be a Project Manager appointed who will manage the whole project to implement Datawarehouse at a facility. There should be someone who is healthcare domain expert. This person will define the requirements in a Business Requirement Document which should be approved by the users. There should be a team of developers depending on the sixe time and budget of the Datawarehouse project. A Datawarehouse architect is the person who plays a key role in any successful implementation of Clinical Datawarehouse in any facility. A data modeler should be the part of team whose task is to develop logical and physical Datawarehouse modeling. Last but not the least an ETL developer who will take care of all the ETL process. In today's time there are many resources who know a lot of things. If the budget is small then one can hire an architect who has the knowledge of ETL and also can build reports and write fancy code.

Step III – Setup of Environment:

Setting up environment is like the backbone of the project. There are many processes involved in creating a Datawarehouse and features like ETL, OLAP Cube, Reporting etc requires setup for environment.

Step IV – Data Modeling

This is yet another crucial task of a Clinical Datawarehouse to ensure good performance and ease to grow. In a Datawarehouse concept there is a logical data model that is build based on user's requirement and then the physical data model is build up. This step also includes identification of all the data sources from which data needs to be pulled into the Datawarehouse.

Step IV – ETL

This is actually the longest step in Datawarehouse development because its time taking to understand all the data sources and their data. Apply business rules and transform it into the new data schema. The ETL developer will provide ETL packages in this phase.

Step V – OLAP Designing

This stage is to design and develop OLAP sources. Brief description of OLAP

Step VI – Report Development

Reports are the key way in which the end users interact with the Data Warehouse. They are just concerted with the output for them to visualize the data and can make decisions in it. Hence it's very important to have the reports developed thinking in mind the specifications given by the users. If the user does not like the reports of if the reports take a lot of time then the whole purpose will be defeated. There are many points that need to be kept in mind in order to develop reports. For example the reports should be quick and easy to be deployed. For that the best way to provide browser based reports so that all users have the ability to run them without getting into the cycle of deployment on their machines. Secondly reports should be as much flexible as possible so as to give extra wings to the users. They should be logically reasonable and sound. The report delivery is very important as many users might want it in Excel or PDF besides the web format. [123-126]

When it comes to giving roles to the users for specific reports, it is a very delicate task. The designing should be made such that it's simple to implement any roles for the users. For example the payroll system reports should only be visible to the accounting department and should not be in any case be assessable to physicians.

Developing Datawarehouse

Let's start creating a Data warehouse to understand more about its concepts and architecture. Data warehouse architecture is probably the most important entity in the whole process as a lot depends on it. If the database schema is not well defined it will result in bad performance and repetitive data. We take into consideration that we know the data very well and have the domain expertise to kick start the Datawarehouse project.

After examining the business requirement and a clear understanding of the environment on which data warehouse will be build, one can disintegrate the source database 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. Business logic is developed in these subject areas which aid in providing a clear overview of the project.

Every subject area has its own importance and the data that corresponds to that subject area can be utilized in developing reports out of it and developing business logic.

In this example below, we will describe many Subject areas and the entities which interact with them. Different schema designs will also be explained on the way describing the subject area.

1. Patient Subject Area

Patient Subject Area Contains the information about the Patient who is being treated.

Characteristic:

Patient subject area is type 2 Dimension in this Data warehouse Schema.

Update Frequency:

Everyday

Reporting

Patient specific reports

Provider Specific reports to understand the expertise and scale of provider.

Table Schema

Column Name	Description
Patient_Id	Primary Key with identity 1
Last_Name	Patients Last Name
First_Name	Patients First Name
MiddleName	Patients Middle Name
Sex	Sex of Patient
DateOfBirth	DOB of Patient
Blood_Group	The blood Group of a patient
AddressLine1	Address
AddressLine2	Address
City	City
State	State
ZipCode	Zip
Country	Country
County	County
Primary_Phone	Primary Phone
Secondary_phone	Secondary Phone
Email_Group	email of the patient
Confidential_Flag	Has confidential information or not
Active_Flag	If the patient is active or not
Vaccine_Id	Foreign Key to Fact_Vaccine Tables Vaccine_Id
Family_History	Details of family history

Schema Pattern Entity
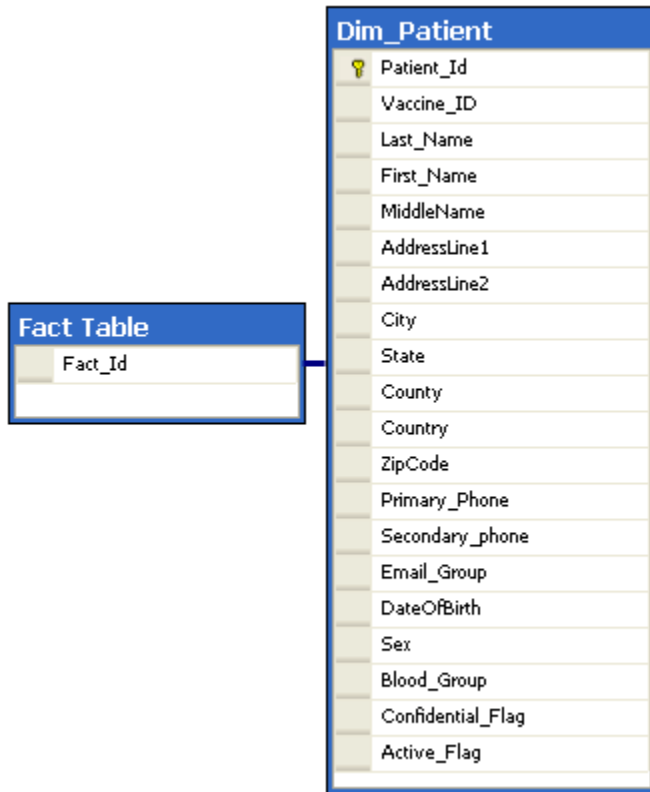
[**Fig. 72**] – **Schema**

UI Entry Screen

Patient information is very sensitive and the UI entry screen needs to have many fields to get patients information. The screen should be made such that it's not complex yet captures all the data points for a patient. There can be scenario that the patient entering the facility is a new patient or it can be an existing patient. In both the cases the UI screens are different and their data path s different. For ex if the patient is new then there will be new data rows created for the patient in all the relevant tables. If the patient is an existing one then not all the data table are going to be updated. Only if the patient has any updated information, the data table is going to be hit. Below are two figures which might be a type of UI for patient entry.

[**Fig. 73**] – **New Patient UI**

Sample Figure of Data Entry Screen for a New Patient Data Entry
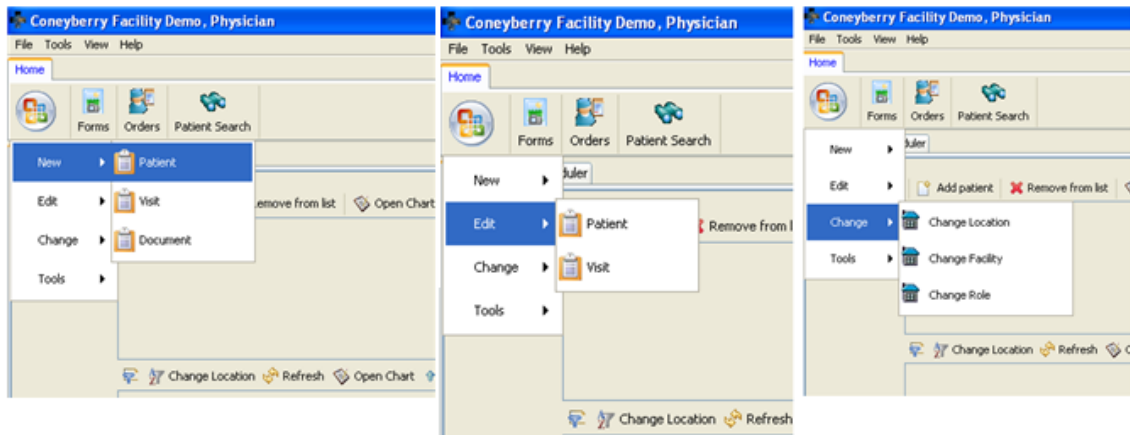
[**Fig. 74**] **– New Patient Data Entry**

Few Actions that can be taken on a patients record in an EMR system. Ex. Create New Patient, Edit existing patient or its visit, Change the location of the facility
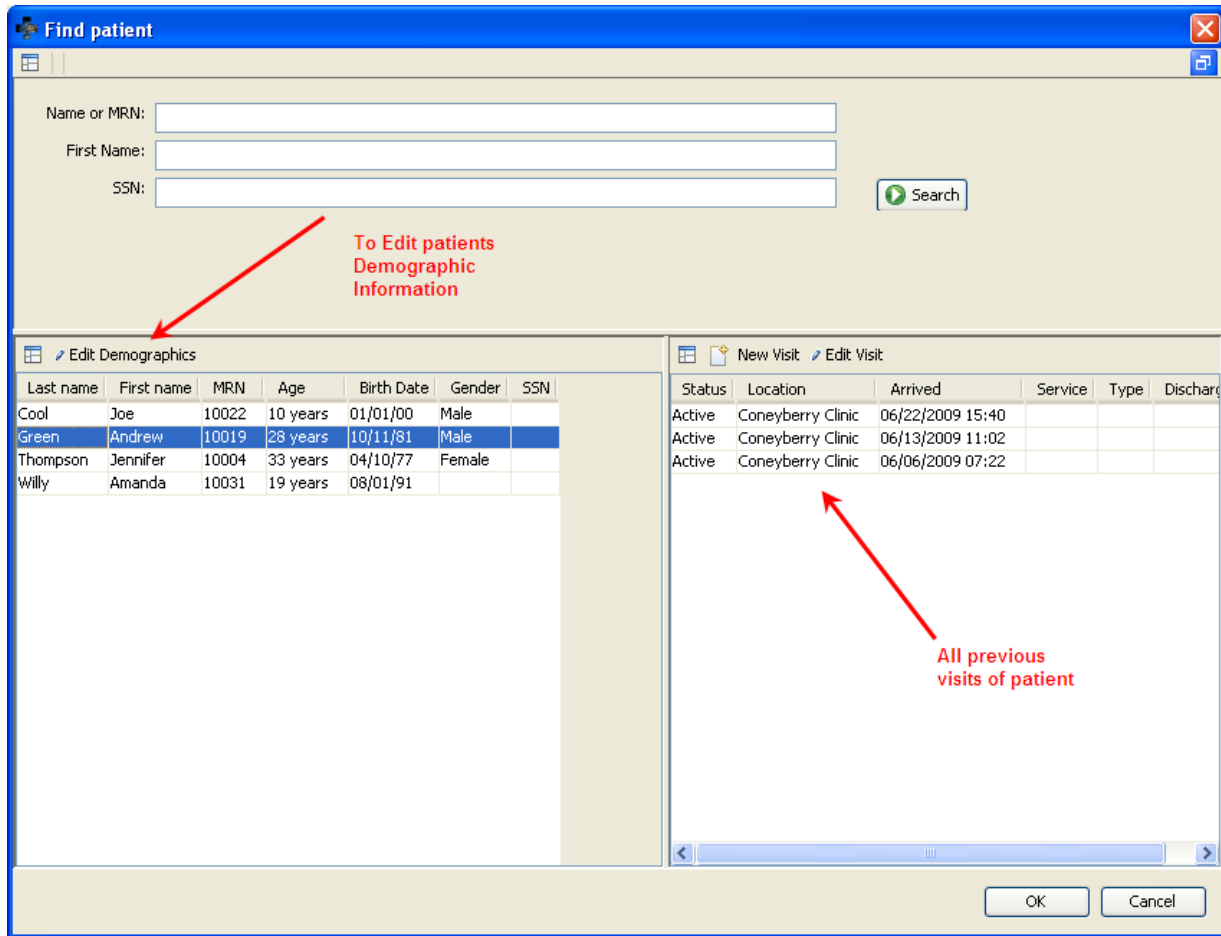
[**Fig. 75**] – **Search patient UI**

Above is the UI for the existing patient. The patient can be searched from the database by various search criteria's. Like in this EMR system the search criteria is name and SSN. The patient's demographic and other information can also be changed using this type of screen. Like in this example screen it shows all the previous visits of the selected patient. In this way it gives a better idea of the patient even before he visits. The physician can view his notes or any lab works or any other documents associated with the patient from selecting any existing patients.

Data Flow

Patient_Id	Last_Name	First_Name	MiddleName	AddressLine1
5000	Green	Andrew		27 Santa Ana Blvd
5001	Smith	Joe		33 Campus Drive

AddressLine2	City	State	County	Country
	Irvine	CA		USA
	Rochester	NY		USA

ZipCode	Primary_Phone	Secondary_phone	Email_Group	DateOfBirth
92707	(900) 909-0909	(900) 909-0909	agreen_1981@yahoo.com	10/11/1981
14623	776-889-2234		smithJ@hotmail.com	5/12/1977

Sex	Blood_Group	Confidential_Flag	Active_Flag	Vaccine_Id
Male	O-	0	-1	1
Male	B+	0	-1	2

2. Provider Subject Area

Provider Subject Area contains the information about the physician or the Supervisor to which the provider reports.

Characteristic:

Provider subject area is a Type 2 Dimension in this Data warehouse Schema.

Update Frequency:

Everyday.

Reporting

PQRI (Physician Quality Reporting Initiative)

Provider specific reports

Table Schema

| Column Name	Description
Provider_Id	Primary Key with identity 1
FullName	Full Name of the Provider
Sex	Sex of the Provider
DateOfBirth	DOB of Provider
Active_Flag	If the provider is active in service
AddressLine1	Address of the provider
AddressLine2	Address of the provider
City	City of Provider
State	State of Provider
ZipCode	Zip Code
Country	Country
County	Country
Primary_Phone	Phone – Primary
Secondary_Phone	Phone – Secondary
Entry_Code	Entry Code of provide
Provider_Type_Code	Code associated with each provider
Primary_Location_ID	Primary Location where the provider practice
Upin	Unique physician identification number
Licence_Expiration_Date	Providers License Exp Date
DEA_Number	Drug Enforcement Administration
Education_ID	Education id of the provider
Specialty1_Name	Specialty of Provider
Specialty1_Code	Specialty Subject Code
Specialty2_Name	Second Specialty of Provider
Specialty2_Code	Second Specialty Code
Credentials	Rating of the Provider

Schema Pattern Entity

Dim_Patient	Dim_Provider
🔑 Patient_Id	🔑 Provider_Id
Vaccine_ID	Full_Name
Last_Name	Sex
First_Name	Date_Of_Birth
MiddleName	Active_Flag
AddressLine1	AddressLine1
AddressLine2	AddressLine2
City	City
State	State
County	ZipCode
Country	Country
ZipCode	County
Primary_Phone	Primary_Phone
Secondary_phone	Secondary_Phone
Email_Group	EntryCode
DateOfBirth	Provider_Type_Code
Sex	Primary_Location_ID
Blood_Group	Upin
Confidential_Flag	Licence_Expiration_Date
Active_Flag	DEA_Number
	Education_ID
Fact Table	Specialty1_Name
Fact_Id	Specialty1_Code
	Specialty2_Name
	Specialty2_Code
	Credentials

[Fig. 76] – Schema

UI Entry Screen

For details of physician the UI screen is something like given below. Here the physician's details are being entered by administrator of the facility.
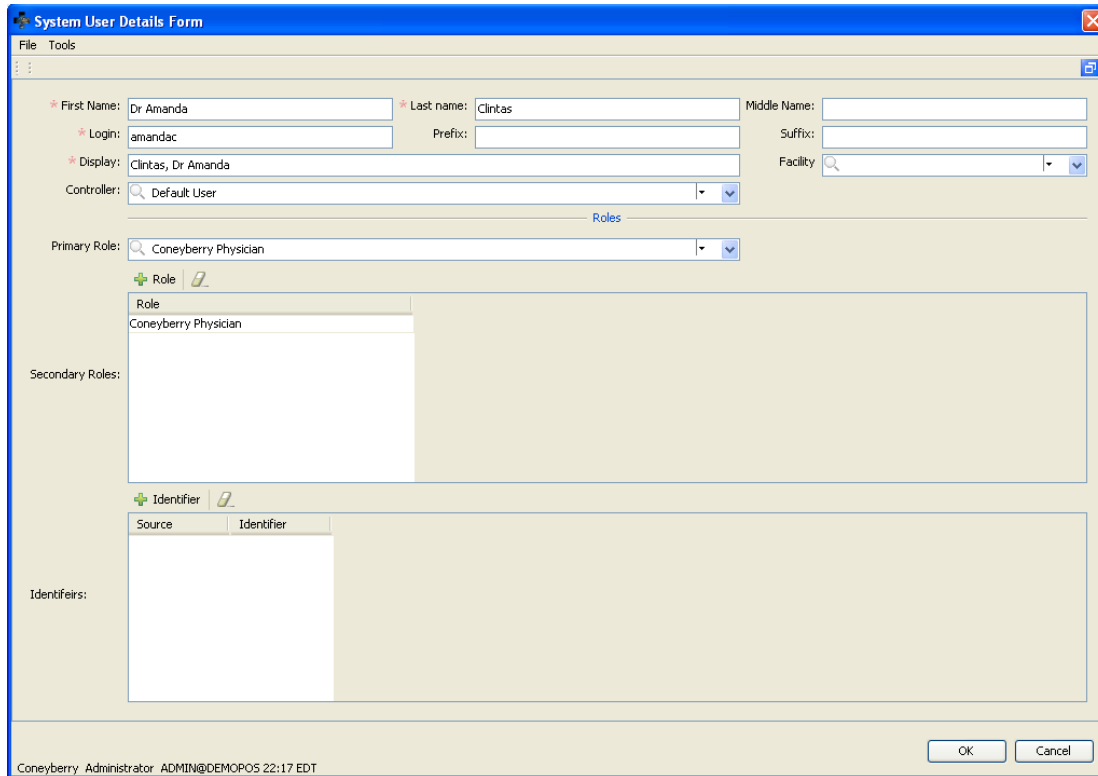
[**Fig. 77**] – **Physicians Screen**

Data Flow

Provider_Id	Full_Name	Sex	Date_Of_Birth	Active_Flag
3003	John Alexander	Male	11/5/1970	-1
3005	Susazane Hoff	Female	3/20/1960	-1

AddressLine1	AddressLine2	City	State	ZipCode
644 Madison Ave Park		Clifton	NJ	07072
554 East Riverside Corp Center		Irvine	CA	92707

Country	County	Primary_Phone	Secondary_Phone	EntryCode
USA	Hudson	445-334-8898		
USA	Orange	557-998-6654		Cardio

Provider_Type_Code	Primary_Location_ID	Upin	Licence_Expiration_Date	DEA_Number
GenPhy	0	PROV01	12/5/2015	

Education_ID	Specialty1_Name	Specialty1_Code	Specialty2_Name	Specialty2_Code	Credentials
LOC02	0		4/15/2018	MDCAR	
MDGP	General Physician	GP			
Cardiology	Cardio	Surgery	CARSUR		

3. Location Subject Area

Location Subject Area has the information about location of the hospital or clinic concerned.

Characteristic:

Location subject area is a Type 2 Dimension in this Data warehouse Schema.

Update Frequency:

Everyday.

Reporting

PQRI (Physician Quality Reporting Initiative)

Provider specific reports

Table Schema

Column Name	Description
Location_Id	Primary Key with identity 1
Location_Country	Country of facility where patient visits the Provider
Location_State	State of facility where patient visits the Provider
Location_County	County of facility where patient visits the Provider
Location_City	City of facility where patient visits the Provider
Location_Division	Division of facility where patient visits the Provider
Location_Building	Building of facility where patient visits the Provider
Location_Room	Room of facility where patient visits the Provider
Location Address	Address of facility where patient visits the Provider

Schema Pattern Entity
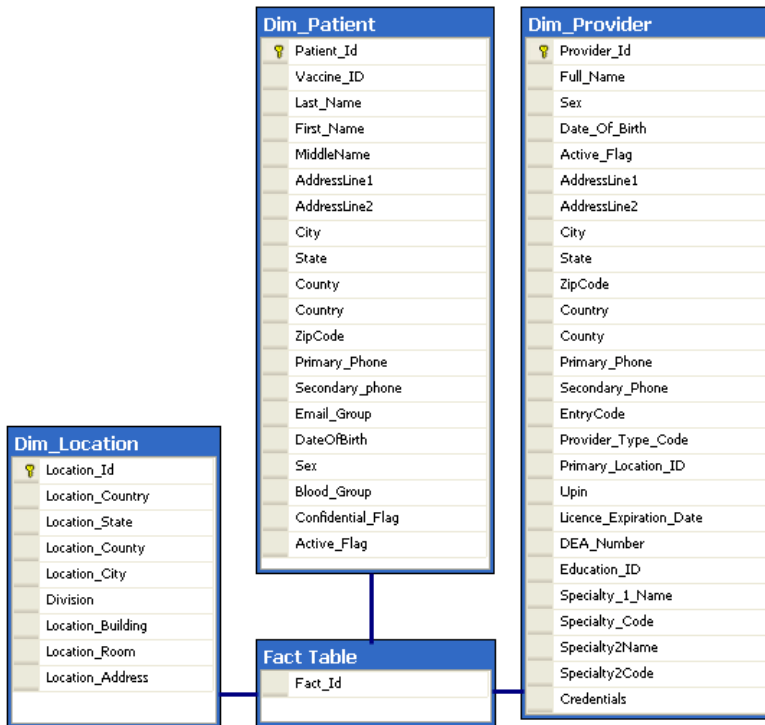
[**Fig. 78**] – **Schema**

Data Flow

Location_Id	Location_Country	Location_State	Location_County	Location_City
1	USA	NY		Rochester
2	USA	NY		NYC
3				Rochester

Location_Division	Location_Building	Location_Room	Location_Address	
General Medicine	BLDG 1 North	1	446 Alex Drive	
Cardiology	BLDG 3	8	36 Park Ave	
Gynecology	BLDG 2 East			

4. Time Subject Area

Time Subject Area has the information about time a particular event occurred.

Characteristic:

Timetable acts as Dimension in this Data warehouse Schema.

Update Frequency:

One time load

Reporting

Used in all reporting.

Schema Pattern Entity
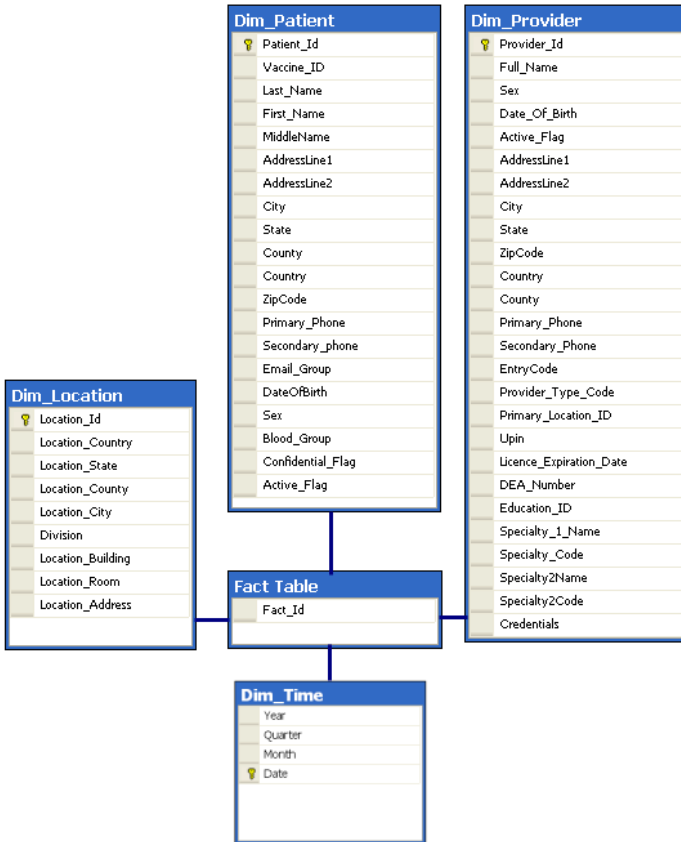
[**Fig. 79**] – **Schema**

Data Flow

Year	Quarter	Month	Date
2010	1	2	2/5/2010
2010	1	2	2/10/2010

5. Lab Results Subject Area

Lab Result Subject Area has the information about lab tests performed and its values for a particular patient.

Characteristic:

Lab Result subject area is Fact in this Data warehouse Schema

Update Frequency:

Every 15 min – ½ hr

Reporting

Patient and its associated Labs Reports.

Lab result specific reports

Table Schema

Column Name	Description
Lab_Result_Id	Primary Key with identity 1
Appointment_Id	Foreign Key to Fact_Appointment Tables Appointment_Id
Patient_Id	Foreign Key to Fact_Patients Tables Patient_Id
Lab_Test_Classification	Classification of Lab Work
Lab_Autorized_By	Id of authorized Provider for that lab work
Lab_Verified_By	Id of provider who verified the lab result
Recorded_Method	Method by which the Lab is recorded
Recording_Source	Source by which the result is recorded like manually/machine
Annotation_1	Comments on the Lab Work
Annotation_2	Comments on the Lab Work
Lab_Result_Stage	What stage is the result in Like Pending, in process etc
Lab_Location	Location of the Lab
Result	Result of the Lab
Result_Numeric_Value	If there is any value associated with the result of the lab
Result_UoM	The unit in which
Performing_Tech	Technician who performed on that lab test
Reference_Range_Text	Reference Range of the test
Reference_Range_Flag	Shows whether the range is in reference range or not

Schema Pattern Entity
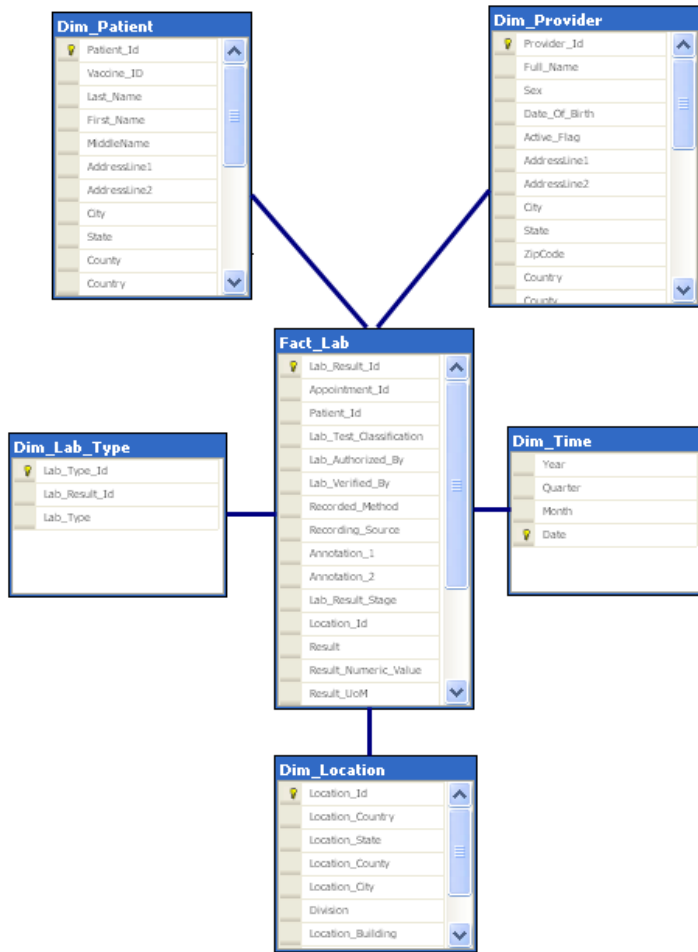
[Fig. 80] – Schema

Hence we see that it has formed a Star Schema and it satisfies the definition of a star schema wherein one Fact Table is surrounded by multiple Dimension Tables with some relationship and makes a start shaped figure. In this figure of star schema the lab result table might be normalized to form a Lab Type table which will contain the definition of Lab Type.

Data Flow

Lab_Result_Id	Appointment_Id	Patient_Id	Lab_Test_Classification	Lab_Authorized_By
1	1	5000	Blood Work	7786
2	1	5000	X-Ray	7786

Lab_Verified_By	Recorded_Method	Recording_Source	Annotation_1	Annotation_2
	Electronic	Automatic	Blood Work is in range	
	Electronic	Automatic	Hairline Fracture in Left Leg X Ray	

Lab_Result_Stage	Lab_Location	Result	Result_Numeric_Value	Result_UoM
	NY		150	mg
	NY			

Performing_Tech	Reference_Range_Text	Reference_Range_Flag
Amanda William	150-200	-1
Mark Rositer		

6. Patient Encrypted Subject Area

Patient Encrypted Subject Area has the sensitive and private patient's information. This information might be used to make any type of judgment about the patient hence it's kept in another secure table whose data is not used generally in reports or any other process.

Characteristic:

Patient Encrypted subject area is a Type 2 Dimension in this Data warehouse Schema.

Update Frequency:

Everyday.

Reporting

Patient and its associated Labs Report

Table Schema

Column Name	Description
Patient_Encrypted_ID	Primary Key with identity 1
Patient_Id	Foreign Key to table Fact_Patient
SSN	SSN of Patient
Race_id	Race identification
Race_Name	Race of Patient
Race_Code	Race code of Patient
Marital_Status_Name	Marital Status Name of Patient
Marital_Status_Code	Marital Status Code for Patient
Religion	Religion of Patient
Primary_Language	Primary Language spoken by the patient
Secondary_Language	Secondary Language spoken by the patient
Living_Will_Flag	If the patient has any Living Will
Eye_Color	Eye Color of patient
Hair_Color	Hair Color of patient
Right_Left_Handed	If the Patient is Right Handed or Left
Citizenship	Patients Citizenship Country
Birth_Location	Location of Birth for the Patient
Adoption_Information	If the patient is adopted
Employment_Status	Employment details of patient
Occupation	Occupation of Patient
Military_Service	If the patient is in Military Service
Needs_Interpreter	If the patient needs an interpreter
Education_Level	Education Level of the Patient
Deceased	If patient is deceased

Schema Pattern Entity
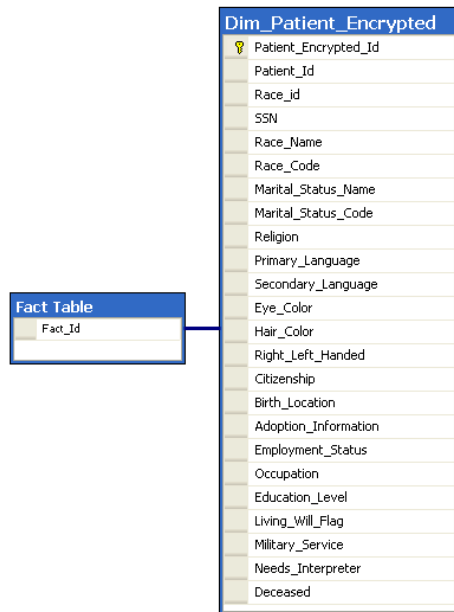
[Fig. 81] – Schema

Data Flow

Patient_Encrypted_Id	Patient_Id	Race_id	SSN	Race_Name
1	5000	887	606-54-8779	White
6	5001	662	778-23-4321	White

Race_Code	Marital_Status_Name	Marital_Status_Code	Religion	Primary_Language
W	Andrew Green	Married	Christian	English
W	Joe Smith	Divorced	Christian	English

Secondary_Language	Eye_Color	Hair_Color	Right_Left_Handed	Citizenship
Spanish	Brown	Black	Right Handed	American
French	Blue	Black	Right Handed	American

Birth_Location	Adoption_Information	Employment_Status	Occupation	Education_Level
Denver, USA		Employed	Sales Manager	Masters
Rochester, NY		Employed	IT Developer	Bachelors

Living_Will_Flag	Military_Service	Needs_Interpreter	Deceased
-1	0	0	0
-1	0	0	

7. Medication Subject Area

This table contains the information about the drug prescribed, till when the prescription is valid, what drugs were prescribed before. What are the different drug allergies to the patient?

Characteristic:

Medication Result subject area is fact in this Data warehouse Schema.

Update Frequency:

Every 15 min – ½ hr

Reporting

Active Medication Reports.

Allergies Reports

Drug analysis and effectiveness

Table Schema

Column Name	Description
Medication_Id	Primary Key with identity 1
Appointment_Id	Foreign Key to Fact_Appointment Table's Patient_Id
Patient_Id	Foreign Key to Fact_Patients Table's Patient_Id
Allergy_Id	Foreign Key to Fact_Allergy Table's Patient_Id
Drug_Date_id	Foreign Key to Fact_Drug Table's Patient_Id
Drug_Name	Drug used for the Medication
Drug_Strength	Strength of Drug
Drug_UoM	Unit of Measure of the medication like mg/ml etc
Drug_Form	Form of Drug
Drug_Quantity	Quantity of Drug
Drug_Route_Of_Admin	The way medication is which given
Drug Manufacture	The pharmacy by which the drug is manufactured
Drug_Start_Date	Date Start of Medication
Drug_End_Date	Date End of Medication
Control_Substance_Flag	Identify if the substance is controlled substance
Generic_Flag	Identify if the Drug is a generic drug
Current Flag	Identify if the drug is current medication

Schema Pattern Entity
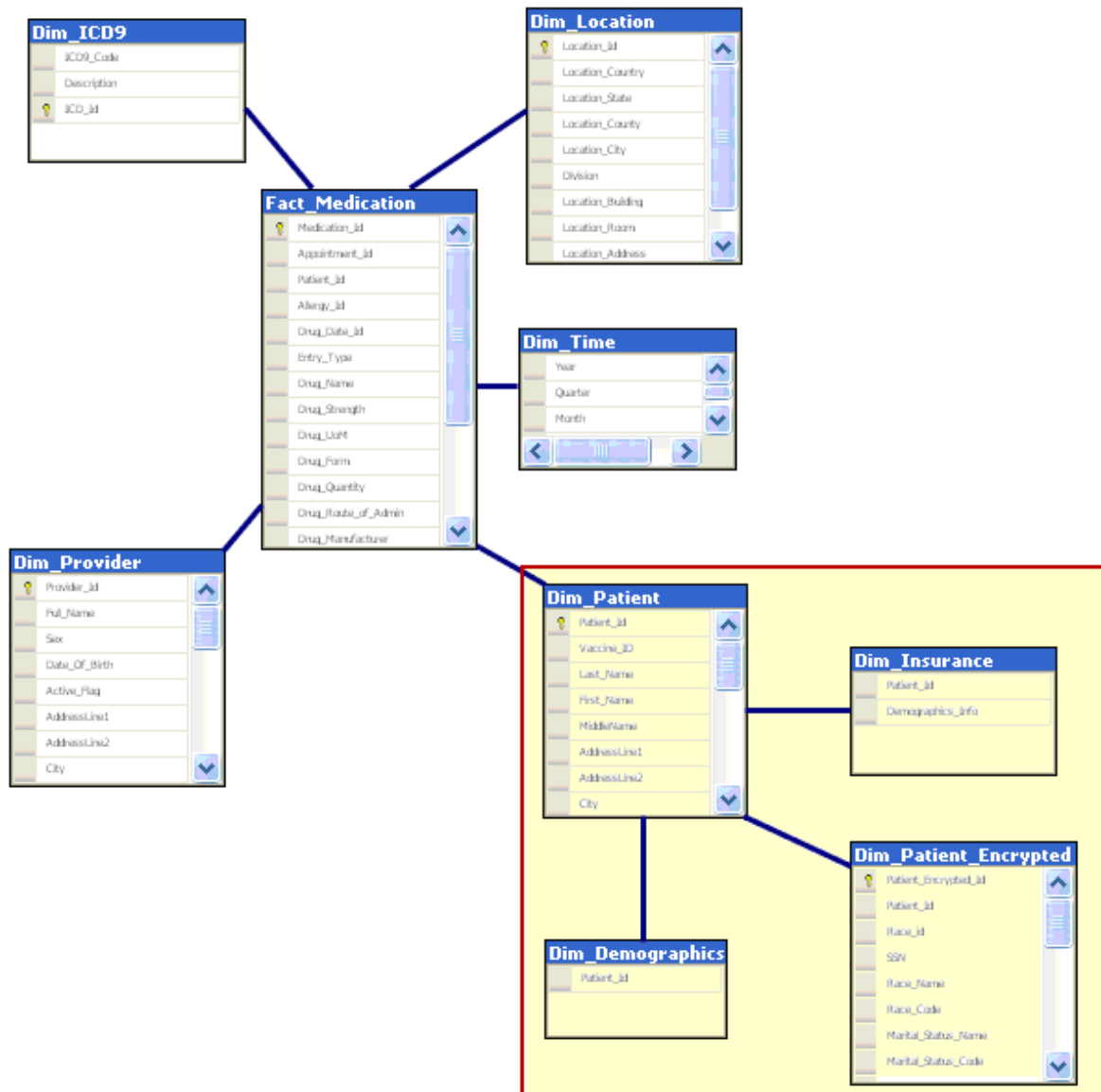
[**Fig. 82**] – **Schema**

UI Entry Screen

The UI entry for medication can be something with a list of all the medications and the physician can use it.
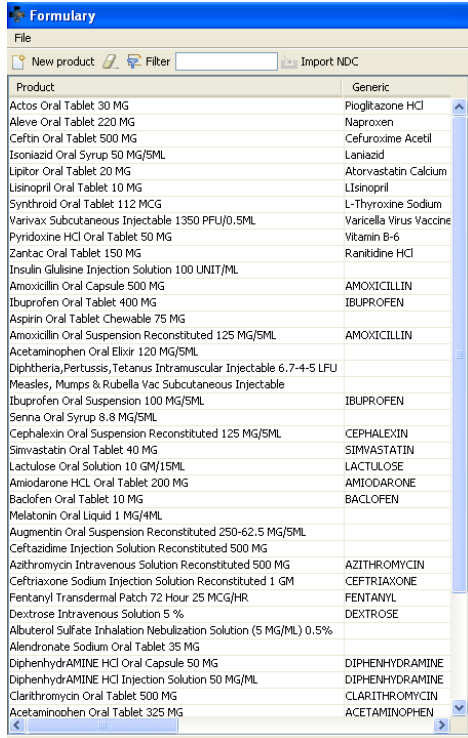
[Fig. 83] – Medication UI

Data Flow

Medication_Id	Appointment_Id	Patient_Id	Allergy_Id	Drug_Date_Id	Drug_Name
600	1	NULL	NULL	NULL	CEFTRIAXONE
601	1	NULL	NULL	NULL	LIsinopril
602	NULL	NULL	NULL	NULL	L-Thyroxine Sodium

Drug_Strength	Drug_UoM	Drug_Form	Drug_Quantity	Drug_Route_of_Admin	Drug_Manufacturer
50	mg	Tablet	10	NULL	PIOGLITAZONE HCL
10	mg	Tablet	500	NULL	LIsinopril
NULL	NULL	NULL	NULL	NULL	NULL

Drug_Start_Date	Drug_End_Date	Control_Substance_Flag	Generic_Flag	Current_Flag
00:00.0	00:00.0	1	1	1
00:00.0	00:00.0	0	1	NULL
NULL	NULL	NULL	NULL	NULL

8. Document Subject Area

This Table contains the result of the test done on patient. For example a x-ray was taken for an patient then the image of the X-ray will be found in this table. So kind of images related to any procedure will be kept in this table. This table in a star schema will be connected to the Central fact table and in a snow flake will be connected to the Lab results table.

Characteristic:

Document subject area is Fact in this Data warehouse Schema.

Update Frequency:

Every 15 min – ½ hr

Reporting

Patient's document specific

Table Schema

Column Name	Description
Doc_Id	Primary Key with identity 1
Appointment_Id	Foreign Key to Fact_Appointment Tables Appointment_Id
Patient_Id	Foreign Key to Fact_Patients Tables Patient_Id
Lab_Id	Id of the Lab Associated with the Patients Encounter
Doc_Type	Type of Document
Doc_Code	Code of the document
Doc_System	If doc is created manual or automatic
Doc_Method	The way document is created
Doc_Entry	Date of which the document was created
Doc_Authorized_By	Authorizing Agency for the Document Uploaded
Doc_Verified_By	Document Verified by
Doc_Date	Document date when created

UI Entry Screen

Some UI screen is required to enter what documents are received by the patient and other resources for that patient like radiology reports x-rays etc. Usually these documents are being scanned or directly sent from labs and other entities through a predefined standard that HIPAA formulates. For example use of HL7 messages or DICOM.

[Fig. 84] – Documents UI

Data Flow

Doc_Id	Lab_Id	Appointment_Id	Patient_Id	Doc_Type
1	1	1	5000	PDF
2	1	1	5000	X-Ray

Doc_Code	Doc_System	Doc_Method	Doc_Entry	Doc_Authorized_By
SCANPDF	Manual		8/1/2010	Dr. John Alexander
SCANX	Manual		7/15/2010	Dr. John Alexander

Doc_Verified_By	Doc_Date
Dr. Crystal Green	2/1/2005
Dr. Syndia Bay	3/5/2001

9. Appointment Subject Area

Appointment is the central fact table in any model. When a patient enters in any doctor's office or hospital the preliminary information filled in the charts is present in this table. This will be the main table governing all the tables. It will have the vitals of the patient. The information in this table might be present in the other tables also. This table has an encounter ID and a patient ID. Both the keys act as a foreign key in all other facts and dimension table and that's how all the tables are joined together.

Characteristic:

Appointment subject area is Fact in this Data warehouse Schema.

Update Frequency:

Every 15 min to ½ hr.

Reporting

Comprehensive patient health report.

Scheduling Reports

Patients History and demographic information reports.

Table Schema

Column Name	Description
Appointment_Id	Primary Key with identity 1
Provider_Id	Foreign Key to Dim_Provider Tables Provider_Id
Patient_Id	Foreign Key to Fact_Patients Tables Patient_Id
Location_Id	Foreign Key to Dim_Location Tables Location_id
Billing_Id	Foreign Key to Dim_Billing Tables Billing_id
Vital_Id	Foreign Key to Dim_Vital Tables Vital_id
Appt_Type	Appointment Type Id
Referring_Provider_Id	Id of the Referring Provider
Department_Id	Id of the Department for which the appointment is booked
Appt_Status	Status of the Appointment
Booking_Method	Method of Booking the Appointment
Appt_Duration	Duration of Appointment
Appt_Cancel_Reason	If the Appointment is Cancellation Id
Admission_Id	Foreign Key to Dim_Admission Tables Admission_id
Discharge_Id	Foreign Key to Dim_Discharge Tables Discharge_id
Appt_date	Appointment Date
Appt_date_Id	Foreign Key to Time_Dimension Table Time_Id

UI Data Entry

Appointment is one of the most important aspects of the EMR/EHR Data warehousing solution since it is the initiating event that is tied to almost all other data sets. For any patients visit, it will create a record for the patient may it be an existing patient or a new patient. Below is the screenshot of the appointment scheduler from PatientOS which is free EMR software. So to get the appointment data there must be an appointment system from some EMR software or other source and the Fact_Appointment Table originates from that data. There can be any pattern of information or any type of information which should be studied first before designing this very important table of a clinical Datawarehouse. If the appointment is for a new patient then there are separate UI screens in the EMR system which will allow entering the basic information of the patient. When new patient arrive at the facility, other important information is grabbed from other screens.

EMR – Concepts & Data Management
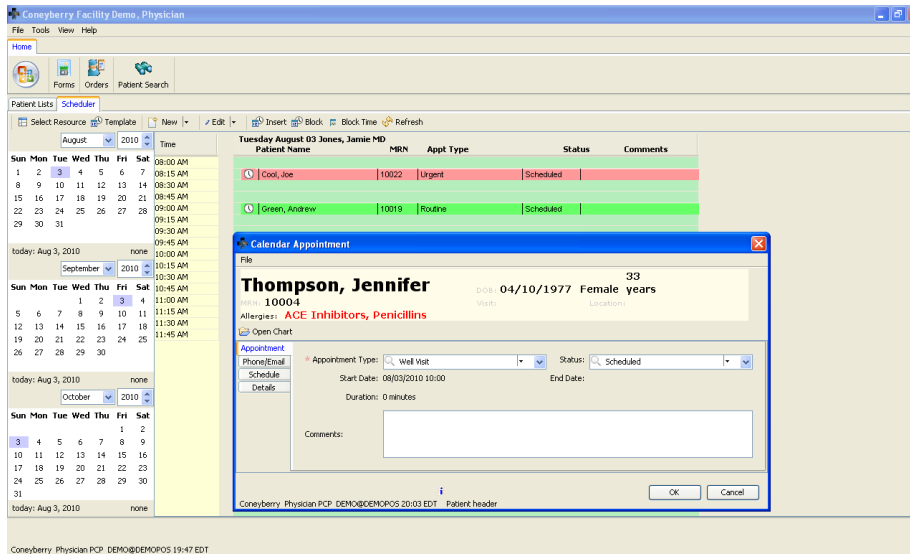
[Fig. 85] – Appointment UI

Data Flow

Appointment_Id	Provider_Id	Patient_Id	Location_Id	Billing_Id
1	3003	5000	2	2
2	3003	5001	3	1

Vital_Id	Appt_Type	Referring_Provider_Id	Department_Id	Appt_Status
7000	Followup			Scheduled
7001	Urgent			Arrived

Booking_Method	Appt_Duration	Appt_Cancel_Reason_Name	Admission_Id	Discharge_Id
Phone	1 Hr		1	1
Phone	1 Hr		2	2

Appt_Date	Appt_Date_Id
	2/5/2010
2/10/2010	2/10/2010

10. Discharge Subject Area

This subject area provides the discharge history of a patient.

Characteristic:

Discharge subject area is Fact in this Data warehouse Schema.

Update Frequency:

Every 15 min – ½ hr

Reporting:

Patient's history and stay

Table Schema

Column Name	Description
Discharge_Id	Primary key with identity 1
Appointment_Id	Foreign Key to Fact_Appointment Tables Appointment_Id
Discharge_Provider_Id	Foreign Key to Dim_Provider Tables Provider_Id
Document_Id	Foreign Key to Fact_Document Tables Document_Id
Discharge_Date_id	Foreign Key to Fact_Discharge Tables Discharge_Date_Id
Discharge_Date	Date when patient was admitted
Discharge_Location	Location where the patient was discharged
Discharge_Comments	Comments at the time of discharged

Data Flow

Discharge_Id	Appointment_Id	Discharge_Provider_Id	Document_Id	Discharge_Date_id
1	1	4456	1	2/15/2010
2	2	3345	2	2/20/2010

Discharge_Date	Discharge_Location	Discharge_Comments
2/15/2010	NY	Dischanrged with new tests recommended
2/20/2010	NY	All Done

11. Admission Subject Area

This subject area provides the Admission history of a patient.

Characteristic:

Admission subject area is Fact in this Data warehouse Schema.

Update Frequency:

Every 15 min – ½ hr

Reporting;

Patient specific reporting can use this subject area.

PQRI

Table Schema

Column Name	Description
Admission_Id	Primary key with identity 1
Appointment_Id	Foreign Key to Fact_Appointment Tables Appointment_Id
Admitting_Provider_Id	Foreign Key to Dim_Provider Tables Provider_Id
Document_Id	Foreign Key to Fact_Document Tables Document_Id
Admission_Date_Id	Foreign Key to Fact_Discharge Tables Discharge_Date_Id
Admission_Date	Date when patient was admitted
Admitting_Location	Location where the patient was admitted
Admitting_Comments	Comments at the time of admission

Data Flow

Admission_Id	Appointment_Id	Admitting_Provider_Id	Admission_Date	Admitting_Location
1	1	4457	2/5/2010	NY
2	2	8898	2/10/2010	NY

Document_Id	Admitting_Comments	Admission_Date_Id
2	Urgent Admission	2/5/2010
3	Regular	2/10/2010

12. Vital Subject Area

This subject area provides the Vital Information of a patient.

Characteristic:

Vital subject area is Fact in this Data warehouse Schema.

Update Frequency:

Every 15 min – ½ hr

Reporting-

Patient Specific Reporting.

Table Schema

Column Name	Description
Vital_Id	Primary Key with identity 1
Appointment_Id	Foreign Key to Fact_Appointment Table's Appointment_Id
Patient_Id	Foreign Key to Fact_Patients Table's Patient_Id
Location_Id	Foreign Key to Dim_Location Table's Location_Id
Vital_Type	Describes kind of vital it is like BP, Height
Vital_Value	Value of Vitals
Vital_Numeric_Value	Numeric Value
Vital_UOM	Unit of measure of Vital

Data Flow

Vital_Id	Appointment_Id	Patient_Id	Location_Id	Vital_Type
7000	1	5000	3	Fever
7001	2	5001	2	BP

Vital_Value	Vital_Numeric_Value	Vital_UOM
	102	F
	120	

13. Vaccine Subject Area

This subject area provides the Vaccine details of patient.

Characteristic:

Vital subject area is Fact in this Data warehouse Schema.

Update Frequency:

Every 15 min – ½ hr

Reporting

HEDIS/ PQRI/ NQF

Table Schema

Column Name	Description
Vaccine_Id	Primary Key
Patient_Id	Foreign Key to Fact_Patients Tables Patient_Id
Vac_Category	Vaccine Category
Vac_Series	Vaccine Series
Vac_Adminstered_Date	date when vaccinated
Vac_Administered_Location	Place where vaccine was given
Vac_Administered_by	Name of the person who administered the vaccine
Vac_Dose	Amount of dose of vaccine
Vac_Adminsteration_Route	The way it was administered
Vac_Administered_Site	The place where vaccine was administered

Data Flow

Patient_Id	Vac_Category	Vac_Series	Vac_Adminstered_Date	Vac_Administered_Location
5000	Measles	Measles	5/11/1985	NY
5001	Hepatitis	A	4/18/1999	NY

Vac_Administered_by	Vac_Dose	Vac_Adminsteration_Route	Vac_Administered_Site	Vaccine_Id
Jayson Reel	4 mg			1
Jayson Reel	2 mg			2

14. Billing Subject Area

This subject area provides the Billing/ Insurance details of a patient.

Characteristic:

Billing subject area is Fact in this Data warehouse Schema.

Update Frequency:

Every 15 min to ½ hr.

Reporting-

Account related reports

Table Schema

Column Name	Description
Billing_Id	Primary Key with identity 1
Insurance_Name	Name of the Insurance of the Patient
Insurance_Code	Code the Insurance of the Patient
Appt_Billing_Location_Name	Name of the billing location
Billng_Area_Name	Name of the Billing Area
Billing_Provider_Specialty_Name	Specialty of the Billing Provider
Billing_Date	Date of billing

Data Flow

Billing_Id	Insurance_Name	Insurance_Code	Appt_Billing_Location_Name	Billng_Area_Name
1	Aetna	AET	NY	
2	BCBS	BCBS	NY	

Billing_Provider_Specialty_Name	Billing_Date
General Medicine	2/5/2010
Cardiology	2/10/2010

15. Allergy Subject Area

This subject area provides the Allergy details for a patient.

Characteristic:

Allergy subject area is Fact in this Data warehouse Schema.

Update Frequency:

Every 15 min – ½ hr

Reporting:

Patient Specific report. Medication report

Table Schema

Column Name	Description
Allergy_Id	Primary Key with identity 1
Patient_Id	Foreign Key to Fact_Patients Patient_Id
Allergy_Drug	Allergy Drug Name
Allergy_Food	Allergy Food Name
Allergy_Environment	Allergy from Environment

The type two dimensions are the dimension which changes over the time slowly so they are also called as slowly changing dimensions. Tables like location, Medication, Physician are examples of SCD. Medication changes over the time. A patient can move to some other branch of the same hospital, Patient can also change his or her physician. All this data can change slowly over the time. But all this data is important and we need to keep track of this data.

Data Flow

Allergy_Id	Patient_Id	Allergy_Drug	Allergy_Food	Allergy_Environment
1	5000	CEFTRIAXONE,Claritin	Nuts	Pollen,Bee
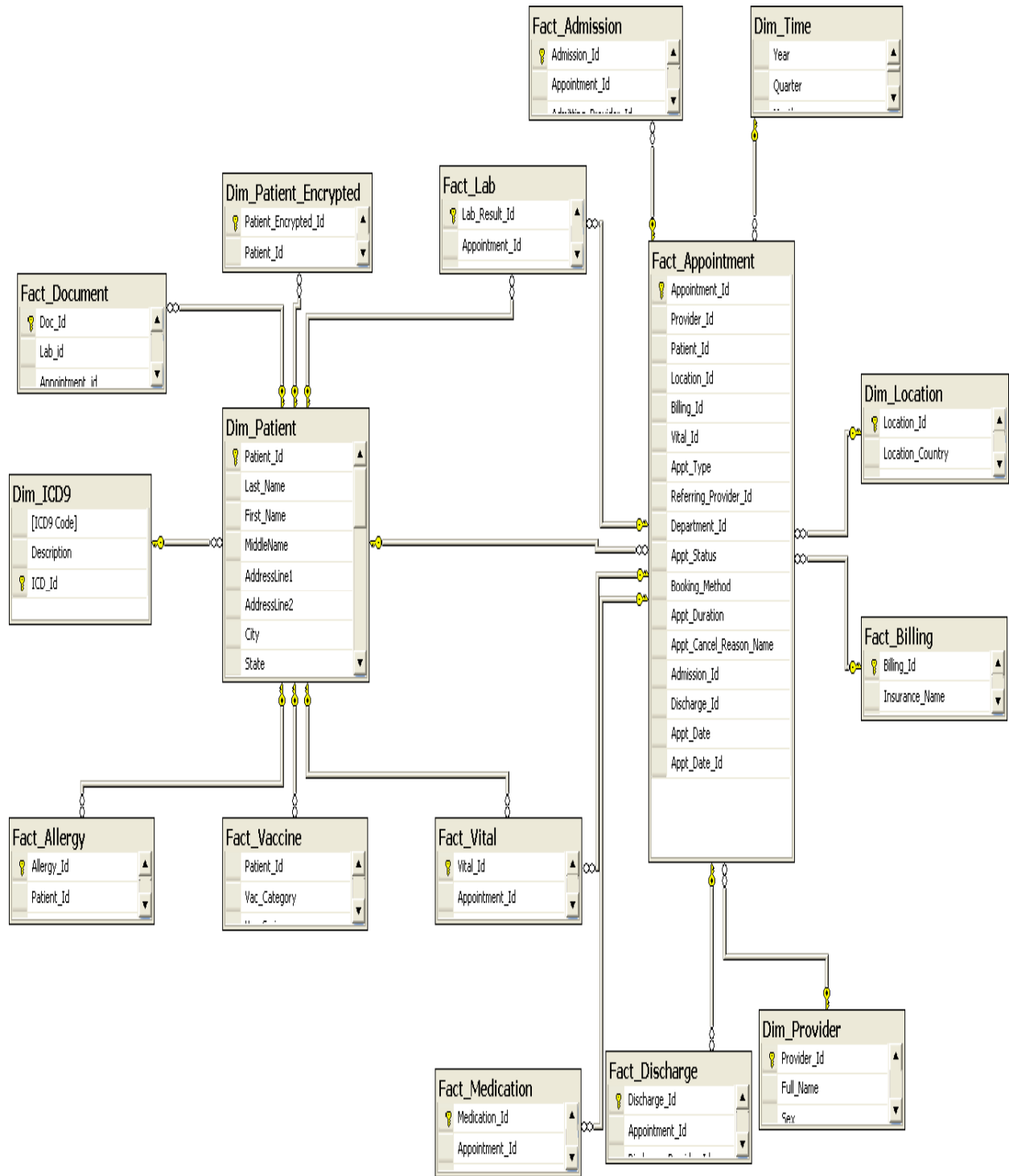
[**Fig. 86**] **– Datawarehouse Schema**

7.6   Advantages of Datawarehouse

Central repository it's a central place for all the data related to an organization. Datawarehouse provides a very good place to combine relevant and related data from separate sources at one place.

Better accessibility- The data warehouse makes the data accessibility very easy. Data in a data warehouse comes from many different sources. May it be different databases or may it be a different physical location of an organization, all the data is loaded into one data warehouse. Thus all the data is accessible in the data warehouse. There is no need to query two different databases for any kind of data as it is easily available in the Datawarehouse.

Increased data consistency- Though the data in a data warehouse comes from various sources, in Datawarehouse all the data gets merged. Merging of the data can take place only when the data is of similar type and consistent. During transformation and after extraction the data is churned to make it consistent all over and then loaded. As a result we get the consistent data throughout the database

 Free from errors- Data in a data warehouse is taken from transactional databases. Transactional database can have many mistakes as this data is entered manually by someone which makes it much more prone to human mistakes. But when the data comes to the data warehouse the data goes through many integrity checks and correctness and then loaded in data warehouse, thus making the data error free.

Data Analysis- Analysis of the data becomes much easier as the Datawarehouse contains history; the data is merged from all over the organization and is consistent throughout. With this kind of data in Datawarehouse we can create several reports and cubes. For example- we can track the effect of a diabetes drug on 100 patients and see its trend how it worked.

There are few reports standards defined which caters to the data analysis of data. These standards are being followed by mostly all the healthcare entities like Physicians, Clearinghouses, Insurance Companies and even patients. Some of the reports which help in analysis are as follows:

A. **PQRI (Physician Quality and Reporting Initiative)**

A voluntary program, PQRI was created in 2007 governed by CMS (Centers for Medicare and Medicaid Services) and helps the physicians and other eligible professionals (Physical and Occupational therapists who are practicing in treatment setting that are subject to the therapy cap) to get a bonus of 2% of their medical billing in 1 year. It applies to those physicians who will provide minimum of 3 measures on a particular group of patients and submits the quality data codes for the services which are paid under the

MPFS (Medicare Physician Free Schedule). For the year 2010 there are 179 measures and 13 measure groups for PQRI.

Each year the PQRI is implemented by CMS through an annual rulemaking process which is published in the Federal Register. [127-130]

B. NQF – National Query Forum

A multi stakeholder organization that is working to improve quality of health care domain through performance measurement and public reporting. It has more than 375 members and is a private nonprofit organization.

You need to measure the healthcare domain in order to make it perfect and improve it. By measuring one can find out what are the pitfalls of a process and then measures can be taken to improve it. When these results are publically reported it becomes easy for the patients to choose best providers, purchasers and insurers.

The way NQF is planning to improve American healthcare is by applying these standards:

a.   To set national priorities and goals for performance improvement.

b.   Endorsing standards to measure and publically reporting on performance.

c.   To promote to attain national goals by means of education and programs.

NQF is a very important step towards a better future of healthcare. The current healthcare in America has serious deficiencies and it's not streamlined. There are top notch physicians and technology to provide excellent health care to the patients but it doesn't fit all in place due to gaps in healthcare. This low quality of healthcare will affect any and all patients. The deficiencies of quality will lead to increased mortality and pain and suffering and hence decrease quality of life. Hence national priorities should be set in place and streamlined in order to gauge the standards of American healthcare. This quality improvement is an ongoing process which involves many individuals and organizations working in many directions in different divisions of healthcare.

NQF does not implement any standards but it sets up national goals and priorities, endorse measures and sponsor education and outreach activities to achieve national goal. [131]

C. HEDIS (Healthcare Effectiveness Data and Information Set)

It's a tool which is used by more then 90% of America's health plans to measure performance on important dimensions of care and service. HEDIS consists of 71 measures which are divided into 8 domains of

healthcare. Its also important for the health plans itself to study their own data by HEDIS so that they can evaluate their performance and growth areas.

Some of the issues which HEDIS measures are as follows:

- Asthma Medication Use
- Persistence of Beta-Blocker Treatment after a Heart Attack
- Controlling High Blood Pressure
- Comprehensive Diabetes Care
- Breast Cancer Screening
- Antidepressant Medication Management
- Childhood and Adolescent Immunization Status
- Advising Smokers to Quit

HEDIS is used by consumers, employers and consultants to evaluate the health plans and select the best plan accordingly. HEDIS data is also referred in most health plans report cards which are published in national magazines and newspapers. [132-133]

Empowering the Users- Because the data is available for use this makes the job of the end users much easier. For example if you want to check the trends of particular drug on your patient. You just need to click and run a report. No one really has to depend on any one else to create the queries or type in a excel sheet manually which takes hours. This makes the life of the doctor so much easier and saves lot of time. Also there are many tools available specifically for business user so that they can just drag and drop the columns and create their own report. This will be possible only if you have a Datawarehouse in place.

History can be kept here- History is important part of the data warehouse. We can learn the trends of business by looking at the historical data and the trends can be used in making the correct decision in future. Thus to be able to store the history and use it for trading is a very big advantage of data warehouse. [134-144]

7.7   Disadvantages of Datawarehouse

Preparation may be time consuming- Creating a data warehouse is not an easy job. Understanding the sources, extraction the data, cleaning and transforming the data and then loading, this whole process can take lot of time.

Requires training- Without training it's not possible to use the data and the overall data warehouse. Training can take a lot of time, money and can be frustrating for users.

Change is not pleasant- Most of the people are happy to be manually creating the reports in excel etc. The change is never pleasant. It is very difficult to make people agree to use new tools and techniques for the data analysis.

Maintenance- Once the data warehouse is created it needs resources to maintain the warehouse. There can be addition of data sources to be extracted, there can be changes in the way the data needs to be transformed all this require someone with the knowledge of the techniques used in the current database. The entire data warehouse is at least updated daily if not every few hrs. There is possibility that these jobs can fail. So the database requires a team to maintain it on everyday basis.

Expensive - Data warehouse creation, maintenance, and training requires a lot of money. It can be a very costly affair for any organizations. The BI tools are also very expensive and so not many companies can afford it. [134-144]

8   Benefits

Simplified Accessibility and Manageability:

The greatest benefit of EMR is its simplified accessibility and manageability. No more going through hundreds of patients and thousands of their records to access the relevant information. No need to manage the paper pile of files and utilize office space and manpower. No more getting reports from labs and other sources and adding then into the present patient file. All this is managed intelligently by the system of EMR. Now a doctor can search any patient in seconds. Can view his history in the order he wants. Can view reports related to the patient and can view his own diagnosis notes in just a click.

Improved Patients care:

Quality of patients care can be highly improved by the use of EMR in the following ways:

- Patients chart Quality can be improved to a great extent.
- Prescription and Medication can be more accurate by the view of patient's history, Insurance information, doctor's referral etc. which is maintained in EMR system easily.
- Reduce human errors encountered due to manual work.
- Integration with other systems can help the patients to ensure their reports are reached to the office automatically and they don't need to trigger the reports by calling the labs.
- Scheduling of patients and managing time can help in allocation time for patients more efficiently and effectively.
- Patients coding is more systematic and hence results in clean data for the physician and the insurance company.
- Patient's money by eliminating use of duplicate clinical services over the time.

Improved Productivity:

Productivity goes hand in hand with EMR system. Everyone is concerned about lowering the office expenses and generating more revenues in this economic market and competition. The office operations can be streamlined and the cost can be reduced to a great extent by the following ways:

- Time is money and a lot of time can be saved using the EMR system to locate patient's record.
- Helping hands for physicians are reduced to a great extent as the same work can be done by few people and more effectively.
- Ease in coordination between accounting and other department's helps in generating invoices on time without any delays and hence results in managed payments.

- Stationary cost is reduced to a great percentage.
- No more dependency on the data. Now the patient's data can be accessed simultaneously by many persons at the same time hence eliminating the dependency.
- Increases productivity for each and every person who is using the system.

More Revenue:

Revenue is the backbone of any business and living and EMR helps in increasing the revenue of any physician's office to a great extent.

- Less Malpractice Premiums: Insurance carriers sometimes provide discount of 10-20% to the providers who use EMR systems.
- No Storage costs: There can be thousands of charts of patients records which as time grows takes a lot of office space and EMR system ensures to make it none.
- Patients satisfaction mean more patients referral and hence more business expansion.

Paperless Office:

Paper is a non renewable resource and when it is used in tons and tons then it makes sense to think how to take step in limiting it. With paperless office you can attain the maximum comfort of manageability and accuracy. It also helps in getting the work done in no time. No more extra manpower to spend the whole energy to manage the charts.

Information Sharing/ Interoperability:

One of the most important benefits of EMR is its ability to link with different systems and aid in information sharing. There has to be a standard defined which all the systems agree upon in order to send messages across. The standard which is used to interact between different system is HL7 (Health Level – 7). These messages provide automatic interactions between related systems. Like EMR would like to send and receive messages from Labs and this will be done by using HL7.

Portability:

Accessing your own system from anywhere in globe is a necessity in today's world. That's what EMR system will extend. The physician can log into the system from anywhere and can perform his tasks.

Decision Making/ Reporting:

Generating reports out of your day today data is very important in order to analyze and take decisions. EMR system provides method which will allow the physicians to develop intelligent reports, and can make wise decisions by studying its data.

Transcription Notes:

With the use of EMR the transcription becomes very easy. Now the physician has to upload the recording which the transcriptionist can pick sitting anywhere by logging in the system. The transcriptionist can then upload the written document which the physician can receive in his system tray and can sign it off there and then.

Quick & Easy:

The use of EMR system will make the work done Quickly and Easily. By using EMR things can be achieved with a great east and at no time. If a physician has to view any patient's data, it will take no 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 EMR by patients, physicians or the health care providers. [145-158]

PQRI/ NQF/ HEDIS:

These are standards which the healthcare entities follow in order to analyze American healthcare in a better and efficient way. EMR provides tools for better reporting and hence maintaining the standards like PQRI/ NQF/ HEDIS which in result provide more return to the physician and other entities related to healthcare.

9   Challenges

Privacy Concerns

"Electronic information of 26.5 million military veterans, including their Social Security numbers and birth dates, health problems etc was stolen from the residence of a Department of Veterans Affairs. " [159-160]

Privacy is one of the biggest questions for any record in electronic format. According to the LA Times, roughly 150 people (from doctors and nurses to technicians and billing clerks) have access to at least part of a patient's records during a hospitalization, and 600,000 payers, providers and other entities that handle providers' billing data have some access. **[Fig. 87 - Privacy]**

In the United States, patient's related information is referred to as Protected Health Information (PHI) and its management is addressed under the Health Insurance Portability and Accountability Act (HIPAA) as well as many local laws.

Hospitals in Charlottesville, VA, have seen a decrease in EMR adoption in states where privacy laws restrict their ability to disclose patient information, according to a study published in the journal Management Science. The study shows that states that have enacted medical privacy laws restricting the ability of hospitals to disclose patient information have seen a reduction in EMR adoption by 11 percent over a three-year period or 24 percent overall. States with no such regulations, on the other hand, experienced a 21 percent gain in hospital EMR adoption. **[Fig. 88 - Detective]**

Although security is an issue, it can be overcome with more efforts. The world runs on web today, starting from checking your bank account to paying your bills to creating any secure account. Extra level of security and complex password can be introduced which will enable the hacking of the data difficult. Also more strict check can be applied on the people who have admin roles and check if there is leakage of information from any end. [161]

Technology Limitations

Limitations in software, hardware and networking technologies has made EMR difficult to affordably implement in small, budget conscious, multiple location healthcare organizations. The storage will be the biggest problem of all. As and as the data is collected for patient it will eat up the memory space. The Data will be either collected locally in the premises where EMR runs or at the server. But this data will be in Terabytes and will keep on growing. It will be a problem transferring files of this magnitude.

There should be a continuous power for the data and should have all the precautionary measures to prevent data loss. [162] [**Fig. 89** - **Computer**]

Training and Process Change

There is always a resistance to change. This is human nature and it will be seen in implementing EMR. People who are using the old paper system will have difficulty to adapt the new way of maintaining the office and data. Although they will feel the comfort but resistance will be seen at the first time. According to the Agency for Healthcare Research and Quality's National Resource Center for Health Information Technology, EMR implementations follow the 80/20 rule; that is, 80% of the work of implementation must be spent on issues of change management, while only 20% is spent on technical issues related to the technology itself. [**Fig. 90** - **Training**]

Financial Concerns

The adoption and setup of an EMR system is an expensive task and needs a lot of finance. The health care organizations will be a little hesitant for the huge investment. Although the long term profits are much more then compared to the paper office but the initial investment will be the hurdle which will stop offices to adopt EMR's. [163] [**Fig. 91** - **Money**]

Increase in Paper Use

Strange but at many places the EMR implementation has increased the use of paper. Where there is a big voice to save paper by implementing EMR, there are some places where this has fallen back. At the annual meeting of American Academy of Orthopedic Surgeons in 2010, Emily Brand, a medical student of university of Louisville, conducted a research at a four physician orthopedic practice and revealed that implementation of EMR system might result in increase of consumption of paper. The reason for this was that the faxed documents were scanned into the EMR system and then printed when required. This resulted in huge paper consumption. It was concluded that practices that need to print documents in order to scan them into an EMR system will consume more paper. Another reason is the inconsistencies in different technologies. For example you can capture a leg design in CAD software but if it's not consistent with the EMR then the EMR will not recognize its output. Hence you will need to take its printout and then scan it to EMR. [164-171]

[**Fig. 92** – **Paper Tower**]

10 Tomorrows World: Green Earth & Data Pool

The voice of the generation is Green Earth. It's never too late to understand the way the earth is depleting day by day, sec by sec. And it's out duty to preserve our beautiful earth and provide it as a gift to the generation coming forward. Green Earth is not a two word expression, rather it's a feeling altogether of thoughts, expressions and focus which will help to move in every possible direction to see the color green, to nurse the natural resources and to take care of mother nature.

One of the major way we call can move in the green direction is to eliminate the use of paper as much as possible. Paper directly reflects depleting of trees and hence hitting the nature big time. There are numerous organizations that are working in this direction to help save earth and to help demonstrate the minimum use of paper. Technology has played a very important role to make this effort easy and to achieve the color green in a most effective way possible.

A lot of paper is used in Healthcare segment and the reason being it's a segment to unimaginable data. This data is of almost of all the living beings that need healthcare at sometime in their life and is unavoidable. To understand and to manage this data throughout the world requires it to be on papers and charts and in every form of paper record possible. Hence it makes sense for us to focus of this segment and with the help of technology, come up to ways to diminish the use of paper to the minimal possible use.

EMR has been a boon in health care segment and has helped in reducing paper to a great extent. The more the use of data seen electronically and in managed format, the less is the paper utilization and printing of loads of data out of which a big chunk is not even relevant, and also less is the use to store data in paper format and adding up of piles of sheets one above another. [172-173] [Fig. 93 – Green Earth]

The future we see for American Healthcare System is when different EHR's will communicate together. The clinical and transactional research information of large patient populations can be shared and utilized to analyze.
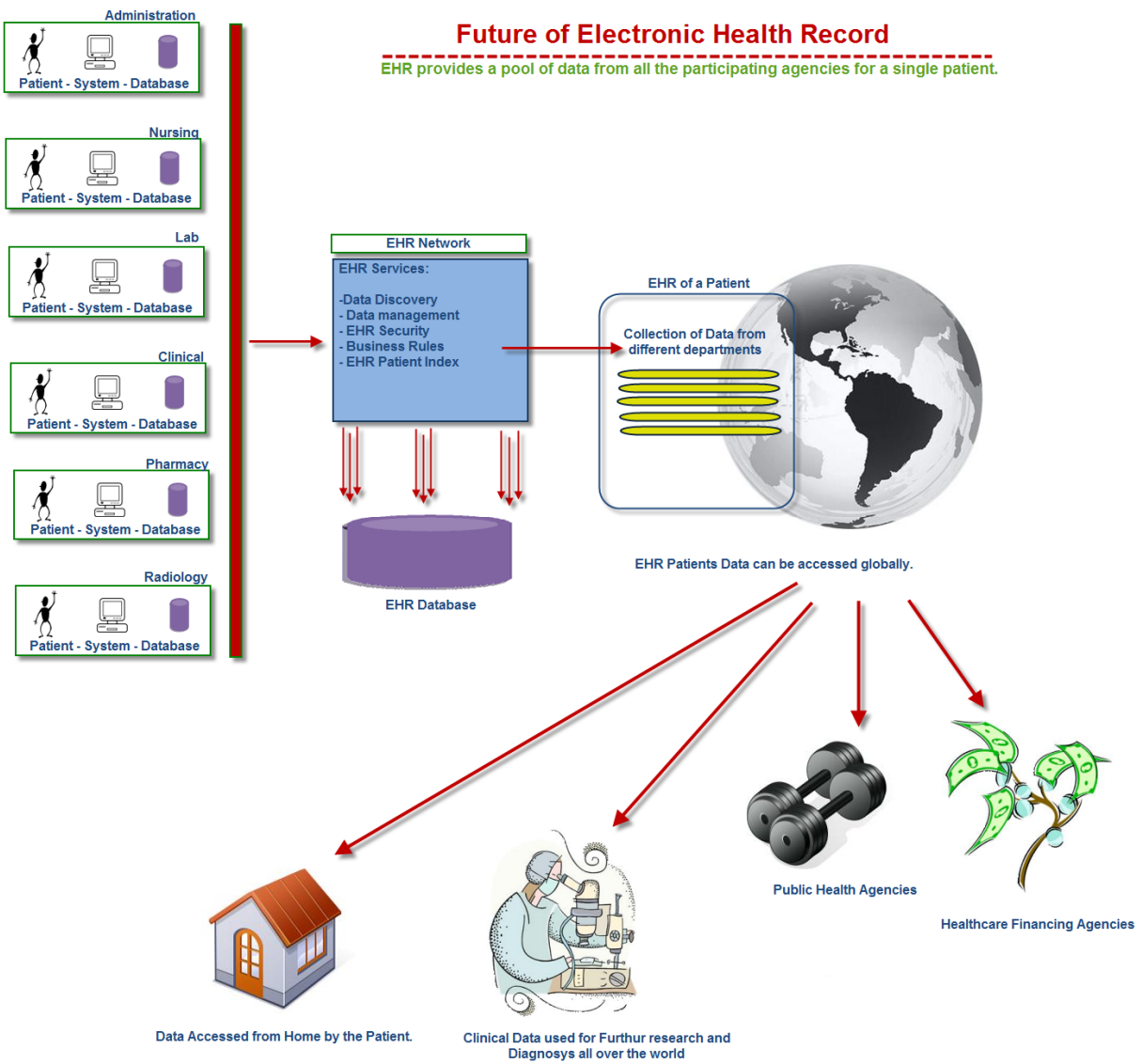
[Fig. 94] – Future EHR

Future EMR's-

With the advancement in technologies, standardization of the medical terms future EMRs will have much more flexibility and usability. We can expect the future EMR's to have following features as compared to the current EMRs

Current EMR's	Future EMR's
• **EMR applications are on personal computers or specific devices provided by vendors.**	• **EMR applications on more Portable devices like iphone, blackberry or PDA with excellent speeds and interaction.**
• **The data entry is more manual typing and mouse clicks.**	• **Data entry will be more voice oriented and extensive use of touch screen.**
• **Information Viewing is more in grid format.**	• **More use of graphics and self explanatory images and diagrams to understand the data.**
• **Technology architecture in underlying EMR in most products is a three tier approach i.e. User Interaction, Application Processing and Data Warehouse**	• **Technology architecture will be more towards decoupling the data layer from the presentation and business layer. In this way the data output will be generic and can be utilized with different presentation models.**
• **Less analytics and the EMR system is more used by the front office or physicians to enter or view or play with the data.**	• **The patients will be more and more computer savvy and will be interacting directly with the EMR system to update the basic information and other data to reduce the physician's time drastically.**
• **Appointment scheduling via calling**	• **The patients can have their own client version of the EMR on the high end phones like PDA and they can update the daily records themselves to be reviewed by the physician.**
• **Patients need to find the Disease information.**	• **Patients with their own client system can provide the details of their disease and relevant web pages for the patient to learn more and more.**
• **Logging through passwords in the EMR system which can be a security threat.**	• **Use of finger prints and other biometric recognition techniques to login into the EMR system and making it more secure. This will compliment the HIPAA rules of confidentiality and integrity of data. [174-175]**

11 References

1. Andrea Santiago, "EMR - What is EMR? ", http://healthcareers.about.com/od/h/g/EMR.htm (accessed March 2, 2010).
2. Trisha Torrey, "What is a Personal Health Record (PHR)?," Jan 07, 2010, http://patients.about.com/od/electronicpatientrecords/a/phr.htm (accessed March 2, 2010).
3. Trisha Torrey, "The Advent of Electronic Patient Health and Medical Record Keeping Systems," Feb 07, 2008, http://patients.about.com/od/electronicpatientrecords/a/EMRPHRhistory.htm (accessed March 2, 2010).
4. Trisha Torrey,"The Benefits of Electronic Medical Records (EMRs)," Feb 08, 2008, http://patients.about.com/od/electronicpatientrecords/a/EMRbenefits.htm (accessed March 20, 2010).
5. David York, "What is an EMR - Electronic Medical Record?," Jan 08, 2008, http://www.disabled-world.com/artman/publish/emr.shtml (accessed March 3, 2010).
6. Dave Garets, Mike Davis, "Electronic Patient Records- EMR's and EHR's," Healthcare Informatics Online, Oct 2005, pp. 1-4, http://www.providersedge.com/ehdocs/ehr_articles/Electronic_Patient_Records-EMRs_and_EHRs.pdf (accessed March 3, 2010).
7. Octavian Purcarea, "Semantic interoperability - Dream or reality?,"Jun 29, 2009, http://blogs.msdn.com/b/ms_emea_health_blog/archive/2009/06/29/semantic-interoperability-dream-or-reality.aspx (accessed March 3, 2010).
8. "Electronic Medical Records, Electronic Health Records, " Oct 12, 2005, http://www.openclinical.org/emr.html (accessed March 3, 2010).
9. "Accurate Definitions -EMR/EPR/EHR,"Feb 26, 2007, http://healthcareinformatics3000feet.blogspot.com/2007/02/accurate-definitions-emreprehr.html (accessed March 3, 2010).
10. Houston Neal, "EHR vs EMR – What's the Difference?," Nov 14, 2008, http://www.softwareadvice.com/articles/medical/ehr-vs-emr-whats-the-difference/ (accessed March 5, 2010).
11. "EMRResource: What's the Difference Between EMR and EHR? ,"Sep 8, 2008, http://emrresource.com/about/ (accessed March 5, 2010).
12. "Electronic Medical Record? Electronic Health Record? What's the Difference?, "Aug 18, 2009, http://www.texmed.org/Template.aspx?id=5278 (accessed March 5, 2010).
13. "Difference Between EHR and EMR," http://www.differencebetween.net/science/health/difference-between-ehr-and-emr/(accessed March 5, 2010).
14. Dave Garets, Mike Davis, "Electronic Medical Records vs. Electronic Health Records Yes, There Is a Difference", Jan 26, 2006, p.3, http://www.himssanalytics.org/docs/wp_emr_ehr.pdf (accessed March 6, 2010).
15. "Electronic Health Records Overview", April 06, Page22, Figure 7, http://www.ncrr.nih.gov/publications/informatics/ehr.pdf (accessed March 6, 2010).
16. Dave Garets, Mike Davis, "Electronic Medical Records vs. Electronic Health Records Yes, There Is a Difference," Jan 26, 2006, p.3, http://www.himssanalytics.org/docs/wp_emr_ehr.pdf (accessed March 6, 2010).
17. "US EMR Adoption Model Trends," p.1, http://www.himssanalytics.org/docs/HA_EMRAM_Overview_ENG.pdf (accessed March 6, 2010).
18. "US EMR Adoption Model," http://www.himssanalytics.org/stagesGraph.html
19. "EMR and HIPAA," June 8, 2010, http://www.emrandhipaa.com/emr-and-hipaa/2010/06/08/think-about-the-problems-with-paper-charting/ (accessed March 6, 2010).
20. "Benefits of EMR," Aug 11, 2008, http://www.msdc.com/EMR_Benefits.htm (accessed March 8, 2010).
21. Cassie Netherfield," Advantages of Purchasing EMR Software,"Feb 17, 2008, http://ezinearticles.com/?Advantages-Of-Purchasing-EMR-Software&id=991778 (accessed March 8, 2010).

22.   Manda Spring ,"EMR Advantages and Disadvantages," Dec 16, 2008,
        http://www.brighthub.com/health/technology/articles/7402.aspx (accessed March 8, 2010).
23.   Trisha Torrey," Limitations of Electronic Patient Record Keeping: Lack of Standardization," Feb 10,
        2008, http://patients.about.com/od/electronicpatientrecords/a/limit-standards.htm (accessed March 8,
        2010).
24.   William R. Hersh, "The Electronic Medical Record: Promises and Problems,",Dec 1995, pp. 1-5,
        http://skynet.ohsu.edu/~hersh/jasis-95-emr.pdf (accessed March 8, 2010).
25.   "Benefits of EMR," Aug 11, 2008, http://www.msdc.com/EMR_Benefits.htm (accessed March 8, 2010).
26.   "EMR Implementation in community hospitals," Jan 2007, pp. 3-15,
        http://www.cpsinet.com/webevent/EMR_wp.pdf (accessed March 9, 2010).
27.   "Paperless office," Wikipedia, http://en.wikipedia.org/wiki/Paperless_office (accessed March 9, 2010).
28.   "Paperless Office – Reducing Paper Creation," http://www.productivity501.com/paperless-office-
        reducing-paper-creation/7391/ (accessed March 9, 2010).
29.   "EMR Products for Your Practice," http://www.cscpaperlessoffice.com/Electronic-Medical-Records.htm
        (accessed March 9, 2010).
30.   "How to Create a Paperless Medical Office," http://www.microwize.com/paperless.htm (accessed March
        9, 2010).
31.   "What a difference an EMR makes: conversion to EMR reduces paper and frees up time and space for
        busy Spokane practice," Health Management Technology, Jan 2002,
        http://findarticles.com/p/articles/mi_m0DUD/is_1_23/ai_81789408/ (accessed March 9, 2010).
32.   "The Paperless Office - Inexpensive EMR," SmartOB, Apr 23, 2009,
        http://smartob.com/paperlessoffice.htm (accessed March 10, 2010).
33.   "Improve Confidentiality With Paperless Electronic Medical Records EMR,"
        http://www.ipaperlessoffice.com/paperless-medical-records.html (accessed March 10, 2010).
34.   Trisha Torrey, "Limitations of Electronic Patient Record Keeping: Privacy and Security Issues," Feb 19,
        2009, http://patients.about.com/od/electronicpatientrecords/a/privacysecurity.htm (accessed March 10,
        2010).
35.   Robert Ellis Smith, "Laptop Hall Of Shame," Sep 07, 2006
        http://www.forbes.com/2006/09/06/laptops-hall-of-shame-cx_res_0907laptops.html (accessed March 15,
        2010).
36.   John Timmer, "State privacy laws may undercut electronic medical records," Apr 14, 2009
        http://arstechnica.com/tech-policy/news/2009/04/state-privacy-laws-may-undercut-electronic-medical-
        records.ars (accessed March 15, 2010).
37.   Anne Zieger, "Study: Stronger privacy rules slow EMR adoption," Apr 20, 2009,
        http://www.fiercehealthit.com/story/study-privacy-rules-slowing-emr-adoption/2009-04-20 (accessed
        March 15, 2010).
38.   Trisha Torrey, "Limitations of Electronic Patient Record Keeping: Privacy and Security Issues," Feb 19,
        2009 , http://patients.about.com/od/electronicpatientrecords/a/privacysecurity.htm (accessed March 15,
        2010).
39.   "Fraud and abuse control program," Cornell University law School, Title 42,Chapter 7, Subchapter XI,
        Part A , § 1320a–7c, http://www.law.cornell.edu/uscode/42/1320a-7c.html (accessed March 15, 2010).
40.   "Medicare Integrity Program," Cornell University law School, Title 42,Chapter 7, Subchapter XVIII, E ,
        § 1395ddd, http://www.law.cornell.edu/uscode/42/1395ddd.html (accessed March 15, 2010).
41.   "Code of Federal Regulations," U.S. Government Printing Office via GPO Access, title 45, vol 1, pp
        710-714, Oct, 2009, http://frwebgate.access.gpo.gov/cgi-bin/get-
        cfr.cgi?YEAR=current&TITLE=45&PART=160&SECTION=103&SUBPART=&TYPE=TEXT
        (accessed March 26, 2010).
42.   "Health Insurance Portability and Accountability Act," Wikipedia, May 23, 2010,
        http://en.wikipedia.org/wiki/Health_Insurance_Portability_and_Accountability_Act (accessed March 26,
        2010).
43.   "An EMR that protects your privacy?," Healthcare Economist, Mar 3, 2008, http://healthcare-
        economist.com/2008/03/03/an-emr-that-protects-your-privacy/ (accessed March 26, 2010).

44.   " Summary of the HIPAA Privacy Rule," U.S. Department of Health & Human Services, http://www.hhs.gov/ocr/privacy/hipaa/understanding/summary/index.html (accessed March 26, 2010).
45.   " Health Information Privacy," U.S. Department of Health & Human Services, http://www.hhs.gov/ocr/privacy/hipaa/understanding/coveredentities/ (accessed March 26, 2010).
46.   "Summary of the HIPAA Privacy Rule," Endoscan.com, http://www.edocscan.com/hipaa-privacy-rule-summary (accessed March 26, 2010).
47.   " For Consumers," U.S. Department of Health & Human Services http://www.hhs.gov/ocr/privacy/hipaa/understanding/consumers/index.html (accessed March 26, 2010).
48.   "Code of Federal Regulations," U.S. Government Printing Office via GPO Access, ,title 45, vol 1, pp 710-714, Oct, 2009, http://frwebgate.access.gpo.gov/cgi-bin/get-cfr.cgi?YEAR=current&TITLE=45&PART=164&SECTION=530&SUBPART=&TYPE=TEXT (accessed March 27, 2010).
49.   "Privacy Software," Wikipedia, May 24, 2010, http://en.wikipedia.org/wiki/Privacy_software (accessed May 27, 2010).
50.   "Health Insurance Portability and Accountability Act," Wikipedia, May 23, 2010 http://en.wikipedia.org/wiki/Health_Insurance_Portability_and_Accountability_Act (accessed May27, 2010).
51.   " The Security Rule," U.S. Department of Health & Human Services, http://www.hhs.gov/ocr/privacy/hipaa/administrative/securityrule/index.html (accessed March 27, 2010).
52.   "Federal Register," Department of Health and Human Services, Vol. 68, No. 34, Feb 20, 2003 / Rules and Regulations, pp. 1-49, http://www.hhs.gov/ocr/privacy/hipaa/administrative/securityrule/securityrulepdf.pdf (accessed April 3, 2010).
53.   "HIPAA Security Series," Department of Health and Human Services, Vol. 2, No. 1, Mar 2007, pp 1-11, http://www.hhs.gov/ocr/privacy/hipaa/administrative/securityrule/security101.pdf (accessed April 3, 2010).
54.   "HIPAA Security Rule Summary," Hitech Survival Guide, http://www.hipaasurvivalguide.com/hipaa-survival-guide-16.php (accessed April 3, 2010).
55.   Department of Health and Human Services, pp 1-3, http://edocket.access.gpo.gov/cfr_2007/octqtr/pdf/45cfr164.308.pdf (accessed April 3, 2010).
56.   Mislav Gluscevic, "Implementing Basic Security Measures", Apr 14, 2003, http://www.net-security.org/article.php?id=458 (accessed April 3, 2010).
57.   "Physical Security Measures," http://www.tpub.com/content/istts/14222/css/14222_96.htm (accessed April 3, 2010).
58.   "Organizational Security," http://www.cert.org/work/organizational_security.html (accessed April 3, 2010).
59.   Debra Little, john Shinder, "10 physical security measures every organization should take," Jul 16, 2007, http://blogs.techrepublic.com.com/10things/?p=106 (accessed April 3, 2010).
60.   "National Provider Identifier Standard (NPI),"April 01, 2010, http://www.cms.gov/NationalProvIdentStand/ (accessed April 3, 2010).
61.   "The HIPAA Enforcement Rule," http://www.hhs.gov/ocr/privacy/hipaa/administrative/enforcementrule/index.html (accessed April 3, 2010).
62.   "Transaction and Code Sets Standards ," May 20, 2010, http://www.cms.gov/TransactionCodeSetsStands/01_Overview.asp#TopOfPage (accessed April 4, 2010).
63.   Kevin Miller,"5 Points to Consider while Selecting an EMR Vendor", March 15, 2010, http://www.emrwire.com/2010/03/15/5-points-to-consider-while-selecting-an-emr-vendor.aspx (accessed April 4, 2010).
64.   Daniel Ray," Electronic Medical Records (EMR) Vendors - Points to Consider", http://www.buzzle.com/articles/electronic-medical-recordsemr-vendors-points-to-consider.html (accessed April 4, 2010).

65. "Selecting the Right EMR Vendor," Healthcare Information and Management Systems Society, 2006, pp. 1-2, http://www.himss.org/content/files/SelectingEMR_Flyer2.pdf (accessed April 4, 2010).

66. "Partners - Patient Education," eClinical Works, http://www.eclinicalworks.com/partners-patientedu.php (accessed April 4, 2010).

67. "What does CCHIT-certification mean? How can you tell if an EHR is CCHIT-certified?," Department of Health and Human Services, Mar 2010, http://questions.cms.hhs.gov/cgi-bin/cmshhs.cfg/php/enduser/std_adp.php?p_faqid=9061&p_created=1207313988 (accessed April 4, 2010).

68. " CCHIT Certification – What Does It Require?," The Certification Commission for Healthcare Information Technology, http://mycourses.med.harvard.edu/ec_res/nt/930820C0-27CB-4D8D-92CA-C5C152738BD9/cchit.pdf (accessed April 4, 2010).

69. "Electronic Medical Records Buyer's Guide," Buyerzone, Apr 2010, http://www.buyerzone.com/software/electronic-records/buyers_guide3.html (accessed April 10, 2010).

70. Kenny Hughes," How to Compare EMR Vendors," http://www.hdsemr.com/compare.htm (accessed April 10, 2010).

71. Kenny Hughes, "Protecting Interests of Physicians In Acquiring and Licensing Electronic Medical Records," http://www.hdsemr.com/ebook.htm (accessed April 10, 2010).

72. Kevin Miller, "How to Select the Right EMR," Jan 11, 2010, http://www.emrwire.com/2010/01/11/how-to-select-the-right-emr.aspx (accessed April 10, 2010).

73. EMR Experts, Inc," EMR Vendor Selection," http://www.emrexperts.com/emr-ebook/vendor-selection.php (accessed April 10, 2010).

74. Robert Lowes, "The best EHRs for small practices," Medical Economics, Sep, 2008, pp. 1-6, http://www.eclinicalworks.com/ecw_website_articles/MedicalEconomics091506.pdf (accessed April 10, 2010).

75. "Top 20 Best in KLAS Awards, 2009, pp. 4-10, sample_Top_20_Best_in_KLAS_Awards_Medical_Equipment_2009_128892169720124732, http://www.klasresearch.com/Store/ReportDetail.aspx?ProductID=533 (accessed April 10, 2010).

76. "Centricity EMR ePriscribing," pp. 1-2, http://www.healthtransformation.net/galleries/special-events/GE%20erx.pdf (accessed April 11, 2010).

77. Christine Hoover, "Electronic Medical Record (EMR) System Review," Oct 30, 2008, pp. 1-19, http://piim.newschool.edu/_media/pdfs/PIIM-RESEARCH_CommercialEMRSystemsReview.pdf (accessed April 11, 2010).

78. "Centricity Physician Office – Practice Management, " Datafusion, http://www.datafuzion.com/repository/GECentricityPM.pdf (accessed April 11, 2010).

79. John McLord, "Usability and Heuristics Practice — Methods For User-centric Software Development," Oct 30, 2008, pp. 1-5, http:/piim.newschool.edu/research/PIIM-RESEARCH (accessed April 11, 2010).

80. EHR Scope,"Connecting Healthcare to Technology," http://www.ehrscope.com/emr-comparison/ (accessed April 11, 2010).

81. "Centricity Electronic Medical Record (EMR)," GE Healthcare, https://www2.gehealthcare.com/portal/site/usen/menuitem.e8b305b80b84c1b4d6354a1074c84130/?vgnextoid=5bb454fbded30210VgnVCM10000024dd1403RCRD&productid=4bb454fbded30210VgnVCM10000024dd1403____ (accessed April 11, 2010).

82. Abraxas, http://www.abraxasmedical.com/Content/company.html (accessed April 11, 2010).

83. "EMR Software-Electronic Medical Records," http://www.abraxasmedical.com/Products/products-emr.html (accessed April 17, 2010).

84. "ARRA Stimulus Package: $20 Billion for Healthcare IT, $4.3 Billion for Smart Grid Technology", Government Technology, Mar 4, 2009, http://www.govtech.com/gt/625084 (accessed April 17, 2010).

85. Matt Cover , "Obesity Rating for Every American Must Be Included in Stimulus-Mandated Electronic Health Records, Says HHS," Jul 14, 2010, http://www.cnsnews.com/news/article/69436 (accessed Sep 17, 2010).

86.   "Electronic Medical Records: Challenges ToThe President's Plan To Digitize Healthcare," University of the Sciences in Philadelphia, Apr 28, 2009, http://www.medicalnewstoday.com/articles/147794.php (accessed April 17, 2010).

87.   "EMRs named top priority in HIMSS survey," Apr 16, 2009, http://www.ehealtheurope.net/news/4751/emrs_named_top_priority_in_himss_survey (accessed April 18, 2010).

88.   "Healthcare IT Continues to Grow, Despite Economy," HIMSS News, http://www.himss.org/ASP/ContentRedirector.asp?ContentId=69099&type=HIMSSNewsItem (accessed April 18, 2010).

89.   "Electronic health record," Wikipedia, Jul 17, 2010, http://en.wikipedia.org/wiki/Electronic_health_record (accessed July 18, 2010).

90.   "Electronic Medical Record," http://www.medical-billing-coding.org/Content234.htm (accessed April 18, 2010).

91.   Rob Roberts, "Cerner works the business circuit," Kansas City Business Journal, October, 2007, http://kansascity.bizjournals.com/kansascity/stories/2007/10/08/story2.html (accessed April 18, 2010).

92.   Martin LaMonica , "Database vendors eye open-source effect," Jul 13, 2005, http://news.cnet.com/Database-vendors-eye-open-source-effect/2100-1012_3-5785645.html (accessed April 24, 2010).

93.   Sarah Lacy, "Taking On the Database Giants,"Feb 6. 2006, http://www.businessweek.com/technology/content/feb2006/tc20060206_918648.htm (accessed April 24, 2010).

94.   John,"The Challenge of creating a Good EMR User Interface," Apr 1, 2009, http://www.emrandhipaa.com/emr-and-hipaa/2009/04/01/the-challenge-of-creating-a-good-emr-user-interface (accessed April 24, 2010).

95.   "Health Seven International," http://www.hl7.org/ (accessed April 24, 2010).

96.   "How does HL7 Works?," iNTERFACEWARE.COM,Dec 2009, http://vimeo.com/8278099 (accessed April 24, 2010).

97.   Rene Spronk,"HL7 Message example: version 2 and version 3," Ringholm, Nov 2007, http://www.ringholm.de/docs/04300_en.htm (accessed April 25, 2010).

98.   "ASC X12", http://www.x12.org/ (accessed April 25, 2010).

99.   Steven C. Horii, "A Nontechnical Introduction to DICOM," Radiological Society of North, July 1997, http://www.rsna.org/technology/dicom/intro/index.cfm (accessed April 25, 2010).

100. Dicom, http://medical.nema.org/ (accessed April 25, 2010).

101. The DICOM Standard, http://www.cabiatl.com/mricro/dicom/index.html (accessed May 8, 2010).

102. Dicom, http://medical.nema.org/dicom/geninfo/Brochure.pdf (accessed May 8, 2010).

103. Sheri Porter, "CCR Standard Heads to Health IT Vendors,Then Physicians," AAFP, Jan,2006, http://www.aafp.org/online/en/home/publications/news/news-now/practice-management/ccrstandard.html (accessed May 8, 2010).

104. "Continuity of Care Record," http://www.ccrstandard.com/ (accessed May 8, 2010).

105. Vince Kuraitis, "Untangling the Electronic Health Data Exchange," Jun 19, 2008, http://e-caremanagement.com/untangling-the-electronic-health-data-exchange/(accessed June 30, 2010).

106. "ASTM E2369 - 05e1 Standard Specification for Continuity of Care Record ," http://www.astm.org/Standards/E2369.htm (accessed May 21, 2010).

107. Gbenga Abimbola , "Clinical Data Warehousing," http://www.clinfowiki.org/wiki/index.php/Clinical_Data_Warehousing (accessed May 21, 2010).

108. Craig Utley, "Designing the Star Schema Database," http://www.ciobriefings.com/Publications/WhitePapers/DesigningtheStarSchemaDatabase/tabid/101/Default.aspx (accessed May 21, 2010).

109. Peter Villiers, "Clinical Data Warehouse Functionality," http://www.lexjansen.com/pharmasug/2000/dmandvis/dm19.pdf (accessed May 21, 2010).

110. "Datawarehouse ETL Extraction," http://www.executionmih.com/data-warehouse/etl-extraction-design.php (accessed May 21, 2010).

111. "Datawarehouse ETL transformation," http://www.executionmih.com/data-warehouse/etl-transformation-design.php (accessed May 22, 2010).
112. "Datawarehouse- Guide to Data Warehousing and Business Intelligence," http://data-warehouses.net/architecture/staging.html (accessed May 22, 2010).
113. "Datawarehouse- Guide to Data Warehousing and Business Intelligence," http://data-warehouses.net/architecture/etlprocess.html   (accessed May 22, 2010).
114. "Slowly Changing Dimension," http://www.1keydata.com/datawarehousing/scd.html (accessed May 22, 2010).
115. Dylan Wan, "How to handle slowly changing dimension in a data model design,"January 13, 2007, http://dylanwan.wordpress.com/2007/01/13/how-to-handle-slowly-changing-dimensions-scds-in-data-model-design/ (accessed May 22, 2010).
116. Brian Walker, "Why use surrogate keys," Jan 2006 ,http://searchsqlserver.techtarget.com/feature/Why-use-surrogate-keys (accessed May 22, 2010)..
117. "Generate Surrogate Key," ETL-Tools.info, http://etl-tools.info/en/examples/generate-surrogate-key.htm (accessed May 23, 2010).
118. "What is Star Schema," http://www.learndatamodeling.com/star.htm (accessed May 23, 2010).
119. "Star schema," LearDataModeling.com, http://www.learndatamodeling.com/star.htm (accessed May 23, 2010).
120. "Star Schema," IBM, March 2004, http://publib.boulder.ibm.com/infocenter/rbhelp/v6r3/index.jsp?topic=/com.ibm.redbrick.doc6.3/wag/wag32.htm (accessed May 23, 2010).
121. "Data Warehousing," http://www.1keydata.com/datawarehousing/datawarehouse.html (accessed May 23, 2010).
122. "Schema Modeling Techniques," http://download.oracle.com/docs/cd/B10500_01/server.920/a96520/schemas.htm (accessed May 28, 2010).
123. "Data Warehousing ," http://www.1keydata.com/datawarehousing/processes.html (accessed May 28, 2010).
124. Ramon Padilla Jr, "Beginning and planning your data-warehousing project,"Dec 6, 2004, http://articles.techrepublic.com.com/5100-10878_11-5155894.html (accessed May 29, 2010).
125. Hari Mailvaganam, "Listen, Listen, Listen to the Stakeholders," http://www.dwreview.com/Articles/Project_Management.html (accessed May 29, 2010).
126. Joe Oates, Sid Adelman , "Data Warehouse Project Management," Jan 2000, http://www.information-management.com/infodirect/20000107/1810-1.html (accessed May 29, 2010).
127. "Physician Quality and Reporting Initiative (PQRI)," Outcome, http://www.outcome.com/pqri.htm (accessed June 5, 2010).
128. FOTO PQRI Registry, http://www.fotoinc.com/assets/pdf/PQRI%20Registry%20Onepage.pdf (accessed June 5, 2010).
129. "Physician Quality Reporting Initiative (PQRI)," Centers for Medicare and Medicaid Services, May, 28, 2010, http://www.cms.gov/PQRI/01_Overview.asp#TopOfPage (accessed June 5, 2010).
130. "Measures Codes", Centers for Medicare and Medicaid Services, May, 28, 2010, https://www.cms.gov/PQRI/15_MeasuresCodes.asp (accessed June 5, 2010).
131. "FAQ's/Help", National Quality Forum, http://www.qualityforum.org/About_NQF/FAQsHelp.aspx#NQF1 (accessed June 6, 2010).
132. Public Reporting - Healthcare Effectiveness Data and Information Set (HEDIS), http://www.setma.com/HEDIS.cfm (accessed June 6, 2010).
133. HEDIS & Quality Measurement, http://www.ncqa.org/tabid/59/default.aspx (accessed June 6, 2010).
134. "Advantages and Disadvantages to Using a Data Warehouse," http://www.exforsys.com/tutorials/data-warehousing/advantages-and-disadvantages-to-using-a-data-warehouse.html (accessed June 6, 2010).
135. "Data Warehouse, " http://infotech.wsu.edu/datawarehouse/ (accessed June 6, 2010).

136. Rick Whiting , "The Data-Warehouse Advantage," July 28, 2003, http://www.informationweek.com/news/software/crm/showArticle.jhtml?articleID=12802974 (accessed June 12, 2010).

137. Rick van der Lans, "The Advantages of Data Warehouse Appliances Revisited," May 04, 2010, http://www.b-eye-network.com/view/13506 (accessed June 12, 2010).

138. "Exploring The Pros and Cons of Data Warehousing," http://www.erpwire.com/erp-articles/data-warehousing-issues.htm (accessed June 12, 2010).

139. "The advantages and disadvantages of Datawarehouse," http://www.whamtech.com/adv_disadv_dw.htm (accessed June 13, 2010).

140. "The Benefits of Data Warehouses," http://www.academictutorials.com/data-warehousing/data-warehousing-benefits.asp (accessed June 13, 2010).

141. "The Disadvantages of a Data Warehouse," http://www.exforsys.com/tutorials/data-warehousing/data-warehouse-disadvantages.html (accessed June 13, 2010).

142. "The advantages and disadvantages of data warehouses," http://www.whamtech.com/adv_disadv_dw.htm (accessed June 13, 2010).

143. "Data Warehouse Issues," http://www.exforsys.com/tutorials/data-warehousing/data-warehouse-issues.html (accessed June 13, 2010).

144. Sid Adelman, Larissa Moss, "Data Warehouse Failures," Oct 01, 2000, http://www.tdan.com/view-articles/4876 (accessed June 25, 2010).

145. "Benefits of EMR," Aug, 2008, http://www.msdc.com/EMR_Benefits.htm (accessed June 25, 2010).

146. "Health Care Industry," http://findarticles.com/p/articles/mi_m0DUD/ (accessed June 25, 2010).

147. Manda Spring , "EMR Advantages and Disadvantages," Dec 16, 2008, http://www.brighthub.com/health/technology/articles/7402.aspx (accessed June 25, 2010).

148. Trisha Torrey, "The Benefits of Electronic Medical Records (EMRs)," Feb 08, 2008, http://patients.about.com/od/electronicpatientrecords/a/EMRbenefits.htm (accessed June 25, 2010).

149. "EMR Benefits, Challenges and Uses," http://model.pih.org/electronic_medical_records/benefits_challenges (accessed June 25, 2010).

150. John," The Advantages of EMR Systems," May 5, 2009, http://www.emrandehr.com/2009/05/05/the-advantages-of-emr-systems/ (accessed July 3, 2010).

151. "EMR Benefits, Challenges and Uses," http://model.pih.org/electronic_medical_records/benefits_challenges (accessed July 3, 2010).

152. Shelley Moore, "What Are the Advantages of Emr?," Jan 5, 2010, ,http://www.ehow.com/facts_5833399_advantages-emr_.html (accessed July 3, 2010).

153. "Advantages & Disadvantages of Emr," http://www.ehow.com/list_5974535_advantages-disadvantages-emr.html (accessed July 3, 2010).

154. Cassie Netherfield," Advantages of Purchasing EMR Software," Feb 17, 2008, http://ezinearticles.com/?Advantages-Of-Purchasing-EMR-Software&id=991778 (accessed July 3, 2010).

155. Trisha Torrey, "The Advent of Electronic Patient Health and Medical Record Keeping System," Feb 07, 2008, http://patients.about.com/od/electronicpatientrecords/a/EMRPHRhistory.htm (accessed July 3, 2010).

156. Trisha Torrey," The Benefits of Electronic Medical Records (EMRs),"Feb 08, 2008, http://patients.about.com/od/electronicpatientrecords/a/EMRbenefits.htm (accessed July 3, 2010).

157. Gregory Makoul, Raymond H. Curry, Paul C. Tang, "The Use of Electronic Medical Records," Journal of the American Medical Informatics Association, Vol 8(6), Feb 09, 2001, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC130071/ (accessed July 4, 2010).

158. William R. Hersh, "The Electronic Medical Record: Promises and Problems," Journal of the American Society for Information Science, Dec 1995, pp.1-5, http://skynet.ohsu.edu/~hersh/jasis-95-emr.pdf (accessed July 4, 2010).

159. Annie Shuppy, "Electronic Records of 26.5 Million Veterans Stolen," Bloomberg, May 22, 2006, http://www.bloomberg.com/apps/news?pid=newsarchive&sid=afP.NFV6CPq0&refer=top_world_news-redirectoldpage (accessed July 4, 2010).

160. "Veterans Affairs Data Theft", Electronic Privacy Informatio Center, July 05, 2006, http://epic.org/privacy/vatheft/ (accessed July 10, 2010).
161. Judy Foreman, "At risk of exposure," Los Angeles,Times, June, 2006, http://articles.latimes.com/2006/jun/26/health/he-privacy26/2 (accessed July 10, 2010).
162. EMR Benefits, Challenges and Uses, http://model.pih.org/electronic_medical_records/benefits_challenges (accessed July 10, 2010).
163. Manda Spring, "EMR Advantages and Disadvantages," December, 2008, http://www.brighthub.com/health/technology/articles/7402.aspx (accessed July 10, 2010).
164. "EMR Benefits, Challenges and Uses,"http://model.pih.org/electronic_medical_records/benefits_challenges (accessed July 10, 2010).
165. Trisha Torrey,"Limitations of Electronic Patient Record Keeping: Lack of Standardization," Feb 10, 2008, http://patients.about.com/od/electronicpatientrecords/a/limit-standards.htm (accessed July 11, 2010).
166. WJ Winkelman, Kevin J Leonard, "Overcoming Structural Constraints to Patient Utilization of Electronic Medical Records: A Critical Review and Proposal for an Evaluation Framework," Journal of the American Medical Informatics Association, Vol. 11, No. 2, Mar-Apr 2004, pp 1-11, www.ncbi.nlm.nih.gov/pmc/articles/PMC353022/pdf/151.pdf (accessed July 11, 2010).
167. James J. Cimino, Jonathan M. Teich, Vimla L. Patel, Jiajie Zhang, "What is wrong with EMR?," pp. 1-4, http://www.google.com/url?sa=t&source=web&cd=5&ved=0CCcQFjAE&url=http%3A%2F%2Facad88.sahs.uth.tmc.edu%2Fresearch%2Fpublications%2FEMR.pdf&ei=nrVITOCpLYH-8Aaoh_XODg&usg=AFQjCNGJiaIk8EgEEDlGmRzpykqkXI_nhA (accessed July 11, 2010).
168. "EMR Implementation Issues," HIMSS, pp. 1-3, http://www.himss.org/content/files/EMR_Imp_issues_032707.pdf (accessed July 11, 2010).
169. Kishore Tipirneni,"The Problem With EMRs," 2006, pp. 1-7, http://www.zipchart.com/News/ProblemwithEMRs.pdf (accessed July 11, 2010).
170. "Initial Paper Usage Increases Following EMR System Implementation," O&P Business News, July 01, 2010, http://www.oandpbusinessnews.com/view.aspx?rid=66142 (accessed July 31, 2010).
171. Susan Childress,"A Good EHR and Practice Management," October, 2009, http://blog.bradfordscott.com/blog/susan-childress (accessed July 31, 2010).
172. "Electronic Health Records Overview," Apr 06, Page22, Figure 7, http://www.ncrr.nih.gov/publications/informatics/ehr.pdf (accessed July 31, 2010).
173. "Improving EMRs: Usability, Usability, Usability," Apr 19, 2009, http://drlyle.blogspot.com/2009/04/improving-emrs-2009.html (accessed July 31, 2010).
174. "Features – Fingerprint Login," Electronic Medical Records, http://www.3plus-emr.com/bio.asp (accessed July 31, 2010).

Image References

1. MC900071262, 00071262.wmf, Microsoft, http://office.microsoft.com/en-us/images/results.aspx?qu=patient#ai:MC900071262|ts:64| (accessed August 7, 2010).
MC900280743, 00280743.wmf, Microsoft, http://office.microsoft.com/en-us/images/results.aspx?qu=file#ai:MC900280743|ts:64| (accessed August 7, 2010).
MC900045097, 00045097.wmf, Microsoft, http://office.microsoft.com/en-us/images/results.aspx?qu=physician#ai:MC900045097| (accessed August 7, 2010).
MC900157323, 00157323.wmf, Microsoft, http://office.microsoft.com/en-us/images/results.aspx?qu=office+work#ai:MC900157323|ts:64| (accessed August 7, 2010).
2. MP900407500, 00407500.jpg, Microsoft,

http://office.microsoft.com/en-us/images/results.aspx?qu=file#ai:MP900407500|ts:64| (accessed August 7, 2010).

3. System Diagram, http://www.binaryspectrum.com/Outsource/healthcare_solutions_overview.html (accessed August 7, 2010).
MC900071262, 00071262.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=patient#ai:MC900071262|ts:64| (accessed August 7, 2010).
MC900280743, 00280743.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=file#ai:MC900280743|ts:64| (accessed August 7, 2010).
MC900045097, 00045097.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=physician#ai:MC900045097| (accessed August 7, 2010).
MC900157323, 00157323.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=office+work#ai:MC900157323|ts:64| (accessed August 7, 2010).
MC900332560, 00332560.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=labs#ai:MC900332560|ts:64| (accessed August 7, 2010).
MC900287245, 00287245.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=computer+systems#ai:MC900287245| (accessed August 7, 2010).
Moving open envelope and letter, 00441456.png, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=message#ai:MC900441456| (accessed August 7, 2010).
Daily calendar, 00434791.png, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=calendar#ai:MC900434791| (accessed August 7, 2010).
MC900238059, 00238059.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=chart#ai:MC900238059| (accessed August 7, 2010).
MC900059372, 00059372.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=accounts#ai:MC900059372| (accessed August 7, 2010).
MM900283668, 00283668.gif,Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=fever#ai:MM900283668| (accessed August 7, 2010).
MC900056876, 00056876.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=insurance#ai:MC900056876| (accessed August 7, 2010).

4. "Electronic Health Records Overview," April 06, Page22, Figure 7,
http://www.ncrr.nih.gov/publications/informatics/ehr.pdf (accessed August 7, 2010).
00078717.wmf, Microsoft,
http://office.microsoft.com/en-us/images/similar.aspx#ai:MC900078717| (accessed August 7, 2010).
00056556.wmf, Microsoft,
http://office.microsoft.com/en-us/images/similar.aspx#ai:MC900056556| (accessed August 7, 2010).
Black and white globe, 10216338.png, Microsoft - PresentationPro,
http://office.microsoft.com/en-us/images/results.aspx?qu=globe#ai:MC910216338| (accessed August 7, 2010).

5. Man overloaded with paperwork, 00432728.jpg, iStockphoto,
http://office.microsoft.com/en-us/images/results.aspx?qu=office+work#ai:MP900432728|ts:64| (accessed August 7, 2010).

6.   MC900053594, 00053594.wmf, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=money%20balance#ai:MC900053594|ts:64|
     (accessed August 7, 2010).
7.   Stacks of gold coins, 00440395.png, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=gold%20coins#ai:MC900440395|ts:64| (accessed
     August 8, 2010).
8.   MP900423689, 00423689.jpg, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=money#ai:MP900423689|ts:64| (accessed
     August 8, 2010).
9.   MC900232587, 00232587.wmf, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=office%20work#ai:MC900232587|ts:64|
     (accessed August 8, 2010).
10. MC900044848, 00044848.wmf, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=meeting#ai:MC900044848|ts:64| (accessed
     August 8, 2010).
11. MC900044846, 00044846.wmf, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=meeting#ai:MC900044846|ts:64| (accessed
     August 8, 2010).
12. Emoticon making decision, 00434411.wmf, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=decision#ai:MC900434411|ts:64| (accessed
     August 8, 2010).
13. MC900040101, 00040101.wmf, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=office#ai:MC900040101|ts:64| (accessed August
     8, 2010).
14. Person and padlock icon, 00442006.png, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=security#ai:MC900442006|ts:64| (accessed
     August 8, 2010).
15. MC900055124, 00055124.wmf, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=cutting%20trees#ai:MC900055124|ts:64|
     (accessed August 8, 2010).
16. Self Created
17.   Smiley emoticon nurse mask, 00440444.wmf, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=mask#ai:MC900440444|ts:64| (accessed August
     8, 2010).
     MC900242037, 00242037.wmf, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=insurance#ai:MC900242037|ts:64| (accessed
     August 8, 2010).
     MC900242035, 00242035.wmf, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=insurance#ai:MC900242035|ts:64| (accessed
     August 8, 2010).
     MC900242033, 00242033.wmf, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=insurance#ai:MC900242033|ts:64| (accessed
     August 8, 2010).
     MC900251663, 00251663.wmf, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=dentist#ai:MC900251663|ts:64| (accessed
     August 8, 2010).
     MC900360972, 00360972.wmf, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=massage#ai:MC900360972|ts:64| (accessed
     August 8, 2010).
     MC900347485, 00347485.wmf, Microsoft,
     http://office.microsoft.com/en-us/images/results.aspx?qu=x%20ray#ai:MC900347485|ts:64| (accessed
     August 8, 2010).

MC900060141, 00060141.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=billing#ai:MC900060141|ts:64| (accessed August 8, 2010).
MC900230752, 00230752.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=billing#ai:MC900230752|ts:64| (accessed August 8, 2010).
MC900293324, 00293324.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=billing#ai:MC900293324|ts:64| (accessed August 8, 2010).

18. "Security Standard Matrix," Center for Medicare and Medicated Services, vol-2,paper 5,Page 10-12 , March 2007,
http://www.hhs.gov/ocr/privacy/hipaa/administrative/securityrule/pprequirements.pdf (accessed August 13, 2010).

19. Self Created

20. Self Created

21. Stick figures with laptops, 00439359.jpg, Fotolia,
http://office.microsoft.com/en-us/images/results.aspx?qu=communication#ai:MC900439359|ts:64| (accessed August 13, 2010).
MP900305748, 00305748.jpg, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=software#ai:MP900305748|ts:64| (accessed August 13, 2010).
MC900334048, 00334048.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=communication#ai:MC900334048|ts:64| (accessed August 13, 2010).
MC900349609, 00349609.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=computer%20hardware#ai:MC900349609|ts:64| (accessed August 13, 2010).
Dollar symbol button, 00433808.png, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=dollar#ai:MC900433808|ts:64 (accessed August 13, 2010).

22. David Raths,"Vetting the Vendors", Page 4,
http://www.healthcare-informatics.com/Media/DocumentLibrary/KLAS_2009_Supplement.pdf (accessed August 13, 2010).

23. David Raths,"Vetting the Vendors", Page 6, http://www.healthcare-informatics.com/Media/DocumentLibrary/KLAS_2009_Supplement.pdf (accessed August 13, 2010).

24. David Raths,"Vetting the Vendors", Page 8,
http://www.healthcare-informatics.com/Media/DocumentLibrary/KLAS_2009_Supplement.pdf (accessed August 13, 2010).

25. David Raths,"Vetting the Vendors", Page 10, http://www.healthcare-informatics.com/Media/DocumentLibrary/KLAS_2009_Supplement.pdf (accessed August 14, 2010).

26. David Raths,"Vetting the Vendors", Page 11, http://www.healthcare-informatics.com/Media/DocumentLibrary/KLAS_2009_Supplement.pdf (accessed August 14, 2010).

27. "The Best of EHRs for small practices," Medical Economics, Page 4, Sep 2006,http://www.eclinicalworks.com/ecw_website_articles/MedicalEconomics091506.pdf (accessed August 14, 2010).

28. GEhealthcare, http://www.gehealthcare.com/euen/cardiology/images/centricity_dpt_mgmt_500.gif (accessed August 14, 2010).

29. GEhealthcare ,http://www.gehealthcare.com/euen/cardiology/images/centricity_workflow_mgmt_500.gif (accessed August 14, 2010).

30. GEhealthcare , http://www.gehealthcare.com/euen/cardiology/images/centricity_patient_mgmt_500.gif (accessed August 14, 2010).

31. Biomed Company News, Nov 2009, http://biomedme.com/biomed-company-news/ge-healthcare-presented-centricity-clinical-notification-system-at-medica-2009_2035.html (accessed August 14, 2010).
32. Abraxas Affiliates and Strategic Alliances, Abraxas Medical Solutions, http://www.abraxasmedical.com/Content/partners.html (accessed August 14, 2010).
33. Abraxas Medical Solutions, http://www.abraxasmedical.com/Products/products-emr.html(accessed August 14, 2010).
34. Abraxas Medical Solutions, http://www.abraxasmedical.com/Products/products-emr.html(accessed August 14, 2010).
35. Abraxas Medical Solutions, http://www.abraxasmedical.com/Products/products-emr.html (accessed August 14, 2010).
36. Abraxas Medical Solutions, http://www.abraxasmedical.com/Products/products-emr.html (accessed August 14, 2010).
37. Abraxas Medical Solutions, http://www.abraxasmedical.com/Products/products-emr.html (accessed August 14, 2010).
38. Abraxas Medical Solutions, http://www.abraxasmedical.com/Products/products-emr.html (accessed August 14, 2010).
39. Abraxas Medical Solutions, http://www.abraxasmedical.com/Products/products-emr.html (accessed August 14, 2010).
40. Abraxas Medical Solutions, http://www.abraxasmedical.com/Products/products-emr.html (accessed August 14, 2010).
41. Partners – Clearing Houses, eClinicalWorks, http://www.eclinicalworks.com/partners-clearing-houses.php (accessed August 14, 2010).
    Partners - Direct Payors, eClinicalWorks, http://www.eclinicalworks.com/partners-direct-payors.php (accessed August 15, 2010).
42. Partners – Appointment Remainder Systems, eClinicalWorks, http://www.eclinicalworks.com/partners-appointment.php (accessed August 15, 2010).
43. Partners – Device Interface, eClinicalWorks, http://www.eclinicalworks.com/partners-medical-devices.php (accessed August 15, 2010).
    Partners - Technology Devices, eClinicalWorks, http://www.eclinicalworks.com/partners-practice-devices.php (accessed August 15, 2010).
    Partners - Decision Support/Clinical Content, eClinicalWorks, http://www.eclinicalworks.com/partners-decisionsupport.php (accessed August 15, 2010).
    Partners - Industry Affiliations, eClinicalWorks, http://www.eclinicalworks.com/partners-emr.php (accessed August 15, 2010).
44. CDSS, eClinicalWorks, http://www.eclinicalworks.com/eclinicalworks8/features-cdss.html (accessed August 15, 2010).
45. Order Sets, eClinicalWorks, http://www.eclinicalworks.com/eclinicalworks8/features-order-sets.html (accessed August 15, 2010).
46. Registry Reporting, eClinicalWorks, http://www.eclinicalworks.com/eclinicalworks8/features-registry.html (accessed August 15, 2010).
47. ePrescribing, eClinicalWorks, http://www.eclinicalworks.com/eclinicalworks8/features-eprescribing.html (accessed August 15, 2010).
48. Progress Notes, eClinicalWorks, http://www.eclinicalworks.com/eclinicalworks8/features-notes.html (accessed August 15, 2010).
49. MC900242033|, 00242033.wmf, Microsoft, http://office.microsoft.com/en-us/images/results.aspx?qu=insurance#ai:MC900242033|ts:64| (accessed August 21, 2010).
    MC900347479, 00347479.wmf, Microsoft, http://office.microsoft.com/en-us/images/results.aspx?qu=x%20ray#ai:MC900347479|ts:64| (accessed August 21, 2010).
    MC900251092, 00251092.wmf, Microsoft,

http://office.microsoft.com/en-us/images/results.aspx?qu=government#ai:MC900251092| (accessed August 21, 2010).

MC900299073, 00299073.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=fever#ai:MC900299073|ts:64| (accessed August 21, 2010).

MC900334024, 00334024.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=nurse#ai:MC900334024|ts:64| (accessed August 21, 2010).

MC900198488, 00198488.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=radiology#ai:MC900198488|ts:64| (accessed August 21, 2010).

50. MP900227700, 00227700.jpg, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=file#ai:MP900227700| (accessed August 21, 2010).

51. Greenway EMR Software-PrimeSuite, mdsmedical, http://www.mdsmedicalsoftware.com/emr-software/electronic-medical-records.php (accessed August 21, 2010).

52. Ophthalmic EMR, http://www.brothersoft.com/ophthalmic-emr---ezchartwriter-69531.html (accessed August 21, 2010).

53. NextGen, http://www.gbscorp.com/images/extra/Neurology01.jpg (accessed August 21, 2010).

54. ForteEMR, http://forteemr.com/images/tablet.jpg (accessed August 21, 2010).

55. York RN, "EMR: The New Future of Portable Health", March,2009
http://yorkstudentrn.wordpress.com/2009/03/27/ (accessed August 21, 2010).

56. Dermatology EMR – NexEMR,
http://www.nextech.com/Products/Dermatology/ElectronicMedicalRecords-NexEMR.aspx (accessed August 21, 2010).

57. NQF- Diabetes Measures, SETMA,
http://www.setma.com/EMRFiles/reports/SETMA.com_NQF_Diabetes_Q1_2010.pdf (accessed August 21, 2010).

58. "QualityMetric Health Survey Sample Reports," QualityMetric,
http://www.qualitymetric.com/WhatWeDo/SampleReports/tabid/259/Default.aspx (accessed August 21, 2010).

59. Periodontal Risk And Disease Analysis,
http://www.previser.com/support/OHIS3/en/Files/Support/Images/PerioPatientReport1.gif (accessed August 21, 2010).

60. Nora Murphy, "Just a Mom Wanting to be Heard",Rare Disease Support, June ,2010
http://rarediseasesupport.org/ (accessed August 22, 2010).

61. Neighbourhood Family DoctorsPA,
http://www.altairtech.com/StoreImages/Dept1/Area4/LabResultsReport.gif (accessed August 22, 2010).

62. Periodontal Risk and Disease Analysis
,http://www.previser.com/support/OHIS3/en/Files/Support/Images/PerioClinicalReport1.gif (accessed August 22, 2010).

63. HL7 from Database, http://www.interfaceware.com/iguana_database.html
System Diagram, http://www.binaryspectrum.com/Outsource/healthcare_solutions_overview.html (accessed August 22, 2010).

MC900071262, 00071262.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=patient#ai:MC900071262|ts:64| (accessed August 22, 2010).

MC900280743, 00280743.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=file#ai:MC900280743|ts:64| (accessed August 22, 2010).

MC900045097, 00045097.wmf, Microsoft,

http://office.microsoft.com/en-us/images/results.aspx?qu=physician#ai:MC900045097| (accessed August 22, 2010).

MC900157323, 00157323.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=office+work#ai:MC900157323|ts:64| (accessed August 22, 2010).

MC900332560, 00332560.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=labs#ai:MC900332560|ts:64| (accessed August 22, 2010).

MC900287245, 00287245.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=computer+systems#ai:MC900287245| (accessed August 22, 2010).

Moving open envelope and letter, 00441456.png, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=message#ai:MC900441456| (accessed August 22, 2010).

Daily calendar, 00434791.png, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=calendar#ai:MC900434791| (accessed August 22, 2010).

MC900238059, 00238059.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=chart#ai:MC900238059| (accessed August 22, 2010).

MC900059372, 00059372.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=accounts#ai:MC900059372| (accessed August 22, 2010).

MM900283668, 00283668.gif,Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=fever#ai:MM900283668| (accessed August 22, 2010).

MC900056876, 00056876.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=insurance#ai:MC900056876| (accessed August 22, 2010).

64. DICOM, http://img.alibaba.com/photo/11266392/DICOM_3_0.jpg (accessed August 22, 2010).

MC900280752, 00280752.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=ultrasound#ai:MC900280752| (accessed August 22, 2010).

MC900312672, 00312672.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=Desktop#ai:MC900312672| (accessed August 22, 2010).

MC900048154, 00048154.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=www#ai:MC900048154| (accessed August 22, 2010).

MC900312646, 00312646.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=www#ai:MC900312646| (accessed August 22, 2010).

Computer server, 00434845.png, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=server#ai:MC900434845| (accessed August 22, 2010).

Printer, 00432661.png, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=printer#ai:MC900432661| (accessed August 22, 2010).

MC900234454, 00234454.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=CD#ai:MC900234454| (accessed August 22, 2010).

65. MATLAB image, http://www.mathworks.com/company/newsletters/digest/nov02/dicom.html (accessed August 22, 2010).
66. Self Created
67. Self Created
68. Self Created
69. Self Created
70. Self Created
71. Self Created
72. Self Created
73. PatientOS, V 0.99, Jan 17, 2010, http://www.patientos.org/ (accessed August 28, 2010).
74. PatientOS, V 0.99, Jan 17, 2010, http://www.patientos.org/ (accessed August 28, 2010).
75. PatientOS, V 0.99, Jan 17, 2010, http://www.patientos.org/ (accessed August 28, 2010).
76. Self Created
77. PatientOS, V 0.99, Jan 17, 2010, http://www.patientos.org/ (accessed August 28, 2010).
78. Self Created
79. Self Created
80. Self Created
81. Self Created
82. Self Created
83. PatientOS, V 0.99, Jan 17, 2010, http://www.patientos.org/ (accessed August 28, 2010).
84. PatientOS, V 0.99, Jan 17, 2010, http://www.patientos.org/ (accessed August 28, 2010).
85. PatientOS, V 0.99, Jan 17, 2010, http://www.patientos.org/ (accessed August 28, 2010).
86. Self Created
87. MC900282916, 00282916.wmf, Microsoft, http://office.microsoft.com/en-us/images/results.aspx?qu=privacy#ai:MC900282916|ts:64| (accessed August 28, 2010).
88. MC900070963, 00070963.wmf, Microsoft, http://office.microsoft.com/en-us/images/results.aspx?qu=privacy#ai:MC900070963|ts:64| (accessed August 28, 2010).
89. MC900018308, 00018308.wmf, Microsoft, http://office.microsoft.com/en-us/images/results.aspx?qu=mouse#ai:MC900018308|ts:64| (accessed August 28, 2010).
90. MC900060140, 00060140.wmf, Microsoft, http://office.microsoft.com/en-us/images/results.aspx?qu=training#ai:MC900060140|ts:64| (accessed August 28, 2010).
91. Rolls of dollar notes, 10216562.jpg, Veer Images, http://office.microsoft.com/en-us/images/results.aspx?qu=money#ai:MP910216562|ts:64| (accessed August 28, 2010).
92. MP900422411, 00422411.jpg, http://office.microsoft.com/en-us/images/results.aspx?qu=paper%20pile#ai:MP900422411|ts:64| (accessed August 28, 2010).
93. Apple shaped Earth globe, 00437633.png, Microsoft, http://office.microsoft.com/en- us/images/results.aspx?qu=green%20earth#ai:MC900437633|ts:64| (accessed August 28, 2010).
94. "Electronic Health Records Overview", April 06, Page22, Figure 7, http://www.ncrr.nih.gov/publications/informatics/ehr.pdf (accessed August 28, 2010).
House icon, 00431627.png, Microsoft, http://office.microsoft.com/en-us/images/results.aspx?qu=Home#ai:MC900431627| (accessed August 28, 2010).
MC900290618, 00290618.wmf, Microsoft, http://office.microsoft.com/en-us/images/results.aspx?qu=research#ai:MC900290618| (accessed August 28, 2010).

Dumbbells free weights, 00433909.png, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=health#ai:MC900433909| (accessed August 28, 2010).
MC900012885, 00012885.wmf, Microsoft,
http://office.microsoft.com/en-us/images/results.aspx?qu=financing#ai:MC900012885| (accessed August 28, 2010).

Note: All Clip Arts are taken from Microsoft Clipart or Online Microsoft Office Clip Arts. The license agreement provides the use of these clipart/ figures for projects and documents. More information at http://explore.live.com/microsoft-service-agreement?ref=none