International
Journal
Of Advanced Research in Engineering& Management (IJAREM)
ISSN: 2456-2033 || PP. 01-06

A Novel Framework for Integrated Implementation of Electronic Health Records

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Abstract: Electronic Health Records (EHR) is digitized version of medical record. Medical record contains a series of documents which contain about the patient's identity, therapy, examination, treatment and other services given to the patient. The EMR should be a part of the Common Heath Centre of a geographic area which is facilitated through cloud storage. These records are accessed, analysed and updated by the corresponding sections in the medical department. There are several benefits of adopting Electronic Medical Record. Firstly, the care given to the computerized notes are easily understood then the physician's handwriting. The error and misunderstanding that is created, can reduce patient's care. Secondly, convenience and efficiency where office and medical staff doesn't have to waste time with paper records. Thirdly, the requirement for storing bulky file cabinets, which free spaces for supplies and equipment. Fourth, patient access where EHR includes patient portal to view their medical information whenever required. Fifth, financial incentives where installing certified EHR can fulfil the requirement for Medicaid and Medicare, making you eligible for various incentives from federal government.

1. Introduction

The goal is to compare different methods employed in the maintenance of EHR which contains all documents about patient's identity, treatment, therapy and other services. These information are accessed through a common platform like cloud services. There are several benefits of adopting Electronic Medical Record. Firstly, quality of care is given where improved computerized notes are often read easier than the physician's handwriting. This reduces error and misinterpretation. Secondly, convenience and efficiency where office and medical staff doesn't have to waste time with paper records. Thirdly, the requirement for storing bulky file cabinets, which free spaces for supplies and equipment. Fourth, patient access where EHR includes patient portal to view their medical information whenever required. Fifth, financial incentives where installing certified EHR can fulfil the requirement for Medicaid and Medicare, making you eligible for various incentives from federal government.

2. Literature Survey

The literature of various implementations of EHRs are discussed below. They include different underlying methodology for each paper.

The method proposed in [1] deals with the creation of electronic records in the following manner. Registration desk receive the patient. Registration desk will create new family folder and create new patient if the patient and the family folder is not registered yet. Else, the Registration desk will search the family folder and create new patient if the family folder is already registered but the patient is not. Later, Registration admin will search the patient's name and enrolled him/her to the clinic. The physician/dentist will examine the patient and create medical record. The medical record consist of the following information. It must contain diagnosis, treatment, drugs prescription, lab order. It can also contain reference to another clinic at the medical organization because they have several clinics. This reference can be called internal reference. It can contain a reference to hospital. This reference can be called external reference. Pharmacist will give drugs as prescribed by the physician/dentist in the prescription. Lab admin will do lab check as ordered by the physician/dentist in the lab order. Referral hospital will receive the patient.

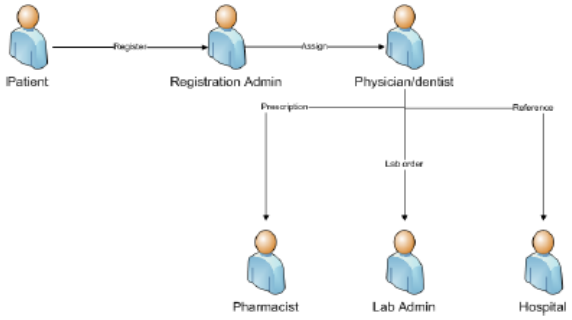

Fig 3.1: Basic work distribution

The authors in [2] included more actors apart from physician and dentist to use the recorded EHRs. The main contributions of our work are listed below. Firstly, selection, collection, and analyses of EHR/EMR papers over the past two decades. Typical tasks and related data are analyzed by the goals and motivation of the particular work. Secondly, extend the data-driven task analysis method to multivariate continuous relationship findings to describe longitudinal trajectory tasks. Thirdly, construct an initial EHR/EMR task taxonomy, using literature- and data-driven methods which could be used for subsequent design and evaluation. The physician deals with sequence of events like diagnosis and treatment and investigate how these sequence co-relate with patient outcome. The clinician provide insight to how the disease would evolve over time and help clinicians understand whether the path lead to better/ worse outcomes.

Analysts & epidemiologist helps analysts and epidemiologists study the data to understand what factors influence the particular outcome. Investigators helps to understand the pattern of events in a population with difference in outcomes.

EHR System based on the Internet is described in [3]. The system is constructed based on the Internet. The system uses three-layer architecture. The bottom layer is an EHR database server. The EHR and other data are stored in this database server. The application are web server are in the middle layer. The application server can complete various complicated management operations and data access. The web server is used to provide web services, exchange data and transfer information with external systems over the Internet. The top layer is the client workstations such as the clinic workstations and query workstations. We can find them in the outpatient hall, registration department, and inpatient department. The doctors, patients, and administrators can also remotely access the system via the Internet. EHR system is integrated with the identity authentication system of the hospital information system. Doctors, patients, and administrators can use the hospital's unified account and password to log in to the system. After obtaining access authorization, doctors can manage the medical records and doctor's advice. Patients can query medical records and doctor's advice. Administrators[4] can manage the users and authorizations. The users, medical records, doctor's advice and other data in the EHR system will be stored in the database. Doctors and patients can query the data anytime, anywhere.

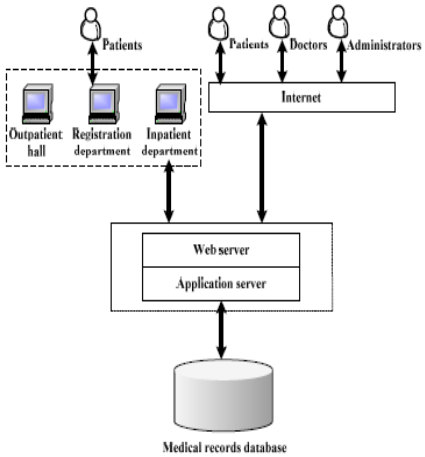

Fig 3.3: EHR implementation over Internet

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3. Methodologies

3.1 Integrated Implementation

The electronic records are created from the combinations of both structured as well as unstructured data. The structured data contains information like ICD[5] (International Classification of Diseases) and CPT (Current Procedural Terminology) codes, electronic prescription and other vital signs. And unstructured data contains information like Visit details which include signs, symptoms, family history, special history like smoking status, etc. They also include details regarding radiology reports like emission and also discharge summary. These data will be collected from a common interface storage platform.

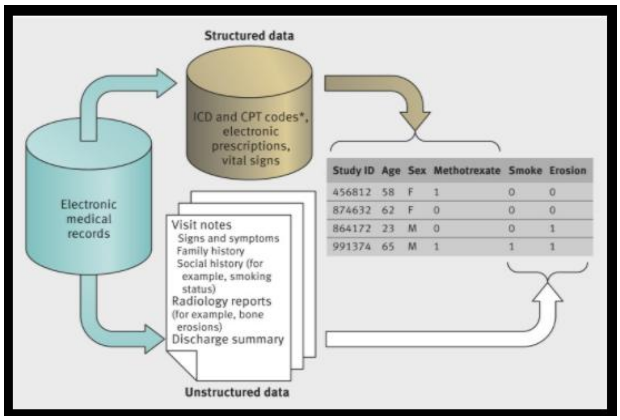

Fig 3.1.1. Extraction of EMR data

These records passed through screening to extract the required data from the EHR. These are they checked with the Data mart containing patient records. Testing sets are already entered into the system to enable the working of the training sets. Training sets are later passed into the classifying algorithm as per the requirement of disease classification. They then, produce the predicted cases to later consider only the validated set.

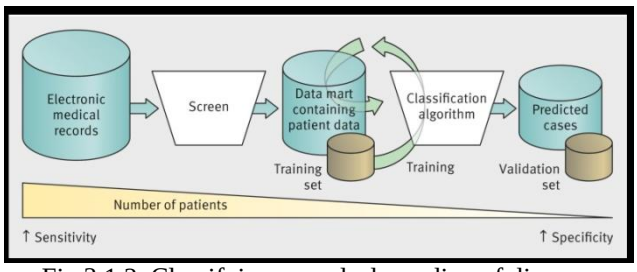

Fig 3.1.2. Classifying records depending of disease

From the validated set, it is then represented as a graph which differentiates the report as structured data only, NLP (National Language Processing) data only and structured and NLP data. These graph later help us in analyzing the growth, discuss on the outcomes and predict the issues in near future.

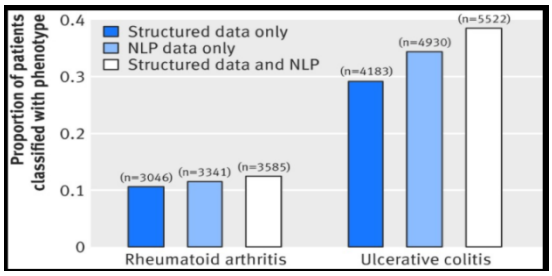

Fig 3.1.3. Result of Iterations

The proposed general phenotyping [6]systems identifies the EHR warehouse, as discussed in section 2. Then, pre-processing is to identify a data mart as discussed in section 3.

Pre-processing is followed by feature extraction where structured and unstructured features are extracted, as explained in section 4. This classification is as a third step.

3.2 Underlying Methodology

The first block of the architecture deals with the true state of the patient. We must first understand that there exist true and false state of a positive or a negative outcome. True Positive is a state where a patient with disease is diagnosed correctly. False Positive is a state where a patient with disease is diagnosed incorrectly. True Negative is a state where a patient without disease is diagnosed correctly. False Negative is a state where a patient without disease is diagnosed incorrectly. In this architecture, the data is taken from the patient and is stored as raw EHR data. This represent healthcare process model. The data from EHR is then fed as the input as the algorithm to classify patients of specified diseases. This yield high throughput because extract raw data is fed instead of bulk unprocessed knowledge to classify patients of specified disease. This can be well understood with the help of an example. The specification is defined using ICD-9 i.e. international classification of diseases in its 9th version.

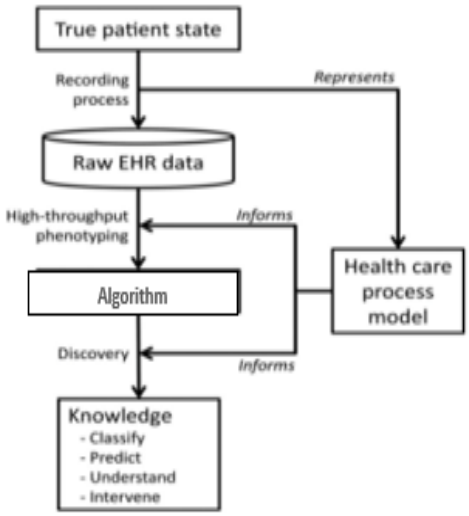

Fig 3.2.1: Basic algorithm working

Using phenotyping algorithms stored in the Phenotype Knowledge Base (PheKB),we conducted independent iterative reviews in order to identify recurrent element within the algorithm definitions. We generalized recurrent elements for drawing candidate patterns.

3.3. Phenotyping Algorithm- Type 1 & 2 Diabetes Classification

Phenotype Algorithms (PAs) are used in research to determine presence of disease. Evaluation of PAs for sensitivity/specificity/predictive values is rarely performed. Phe Valuator uses diagnostic predictive modeling to perform PA evaluation.

The architecture has 3 sections from where data flows in and out. The first section is EHR which is stored in separate computers in particular organization. These information are then extracted and stored in the main server which could be an integrated platform to share or access data. The data from the server is later passed through a plug-in. Plug-ins are software that allows us to retrieve data in a customized fashion. These data are then mapped to the patient data.

The other end of the block contains Clinical Knowledge/ Medical Standards. Here, these are for the doctors. Two blocks are integrated to pass into the Ontology Editor/ Knowledgebase framework. Ontology resources are the physicians who receive a set of data with corresponding outcomes, alternatives, treatments, symptoms, prescription, etc. are analyzed. The first block contains Phenotype Algorithm Specified Ontology,

which includes specified physician for a particular disease the algorithm is running for. The second block is SNOMED CT-AU Ontology which contains systematically organized computer collection of medical terms and definitions provided with codes by ICD-9 (International Classification of Disease in its 9th version).

The middle block contains the algorithm to classify the data which has 2 inputs, one- the queries entered and two- the raw medical data. After passing through the designated algorithm, they are then checked by the Quest which could be an Ontology Reasoner/ Process Engine. He, with the knowledge and the individual ontological records later determine the final output of classifying patients of particular disease.

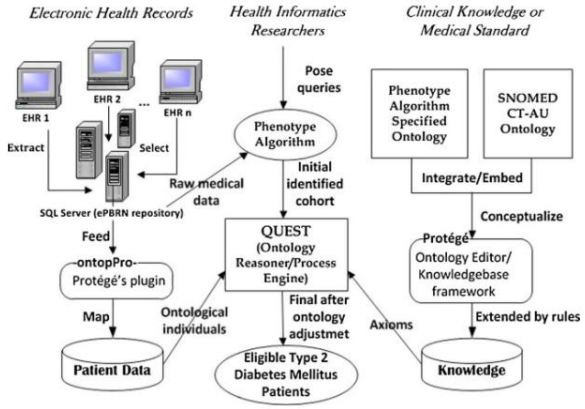

Fig 3.3.1 Phenotype Algorithm Type 1& 2 Diabetes Classification

3.4 Phenotying Algorithm- Cancer Diagnosis

This is based on HDFS (Hadoop Distributed File System) and 2 Phase Map-Reduce. Phenotype algorithm uses NLP (National Language Processing) tool which is used to analyze and classify the cancer patientdata like gene mapping, age related data, images and ultrasonic frequency processing and other personal histories.

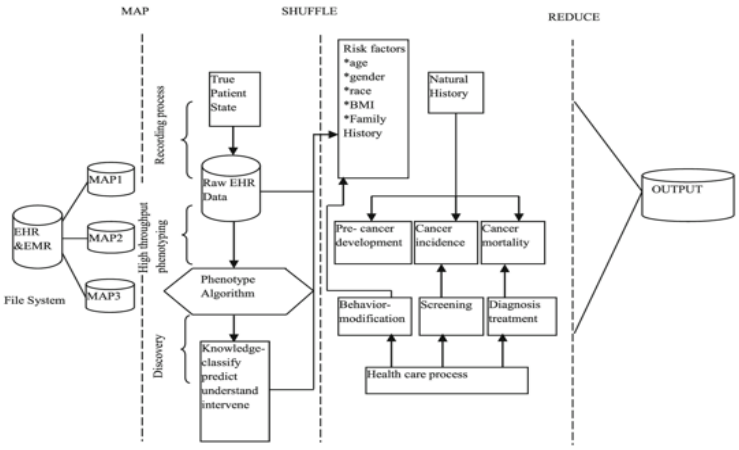

Fig. 3.4.1. Phenotype Algorithm for Cancer Diagnosis

The Map Reduce [7] model processes large unstructured data sets with a distributed algorithm on a Hadoop cluster. Here, EHR/EMR is set up as a Distributed File System. They are mapped into several set of data depending upon the requirement from the phenotype algorithm. In coming section, there are 3 processes. Firstly Recording process, where patients which are in true state is taken and their corresponding raw EHR data is formed. Second process is of high throughput phenotyping where this raw EHR data is fed as the input to the phenotyping algorithm. Their output leads to the third process discovery of knowledge, which could be used to classify, predict, understand or also intervene the results.

Next, comes the shuffle[8] phase. Here, the healthcare process which is the bottom-most block yields output depending on the Behaviour modification, screening and diagnosis treatment. Behaviour modification

deals with risk factors which is formed from classified knowledge and raw EHR data. Screening is the method of evaluation, depending upon the underlying results. Natural history yields 3 kinds of outputs which include pre-cancer development required patients, cancer incidence (rate of new cancer cases) and cancer mortality (rate of death due to cancer). The result of screening can yield cancer incidence and output of diagnosis treatment can list down the patients recovered, patients still under treatment and patients dead. The outcome of this is reduced to derive the graph or report of medical records dealing with cancer diagnosis which can be later analysed.

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