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Design of a Decision Support System in Electronic Medical Record Using Structured Query Language

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Abstract. Healthcare sector contains large volumes of data. A large volume of health related data is in the form of graphics, images and text. Clinical decision support system is an old area of research but current Electronic Medical Records (EMR) has no decision support system that could create a proper relationship between relevant treatments against their respective diagnoses. This research has a unique idea to incorporate decision support system in EMR. Paper based environment has already been replaced with EMR but still medical providers are facing problems by choosing less relevant procedures, which may not produce the optimal result. Due to this reason claims rejection rate are high and payments are low in numbers. Focus of this research work is to provide a decision support system and to deliver focused knowledge in the form of relationship between diagnoses and their procedures. The system follows three steps to make a decision. Firstly, it checks the past claims for diagnosis and treatments. Secondly, it explores the National Coverage Determination (NCD) and Local Coverage Determination (LCD) data and finally displays the relevant combination of procedures and diagnoses for doctor or physician as a suggestion or recommendation. If relevant procedures are not found then it checks on the basis of doctors with the same specialty and their recent diagnoses, and then maintains a complete knowledge base for future reference. The proposed system has the ability to merge easily in EMR because of its highly dynamic architecture. The Past medical history of the patient has been retrieved by decision support system (DSS) and doctor can see the previous diagnoses and treatments and can also generate the supporting treatments relevant to the diagnoses. The system efficiency has been tested on 994 medical claims. In these medical claims the total numbers of procedures was 246 and diagnoses were 501, out of which 157 procedures and 480 diagnoses have been selected by the system. The accuracy of the system regarding procedures is 63.82% and diagnosis is 95.8%. The system has provided a great deal of benefit to the doctors as it has saved them time and also reduced the chances of selecting invalid procedures by mistake.

Keywords: Decision Support System in Electronic Medical Billing, Decision Support System in Electronic Medical Record, Artificial Intelligence in Medical Billing

1. Introduction

Public as well as private sector have contributed a lot in healthcare domain by providing healthcare facilities to patients in United States. The general model followed in US is that health care services are provided by the medical practitioners or hospitals and the bills are forwarded to insurance companies as claims. Health insurance is provided by private and public sector which includes Medicaid, Medicare, Tricare, the Children's Health Insurance Program and the Veterans Health Administration.

For physicians and medical providers many clinical decision support systems (CDSS or CDS) have been designed to support and improve their decision making abilities. These are usually interactive computer programs. Clinical Decision Support systems improve healthcare choices or decisions for physicians on the basis of observations and health related domain knowledge. There are many AI systems that have been designed and developed such as Oncocin [9], DXPlain [4], Present illness program (PIP), Causal Associational Networks (CASNET), Acid-Base and Electrolyte program (Abel), Quick Medical Reference (QMR) [5], Internist [18], Mycin [10] and AAPHelp etc.

Electronic Medical Record (EMR) is also known as Electronic Health Record (EHR), Electronic HealthCare Record (EHCR), Computerized Patient Record (CPR) and Electronic Patient Record (EPR). EMR is basically meant for: a) Electronic collection of patient's record that includes past medical history and current diagnosis and treatments. b) Easy availability of healthcare related information for any individual. c)

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Electronic computerized storage of data. d) Non-redundant data. e) Clinical, social, financial and demographics, health and insurance related data. f) Complete and accurate availability of health related data for a life time of a patient. Symptoms are related to diverse test results and past medical history of the patient which then fallout into diagnosis (DX Codes or International Classification of Diseases). In relation with the International Classification of Diseases (ICDs), medical practitioners suggest treatments in the form of CPT(s) on the medical bill or medical claim. Payment(s) are made in relation with those functional CPTs by the insurance companies. A simple graphical format of this process is given below in Fig. 1.

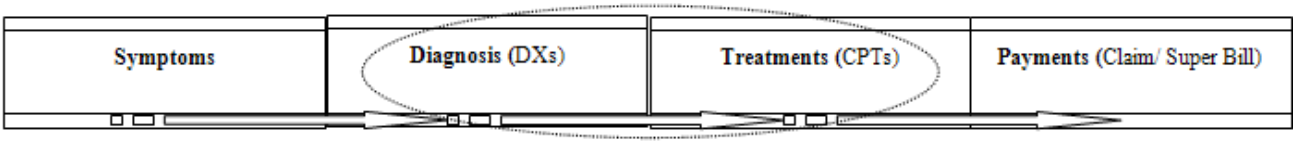

Fig. 1: Decision Support System Scope

2. Rule Based System and Decision Support System

The proposed system works on the basis of three important points a) A Knowledge Base or Rule Base. B) An Interpreter and c) Working Memory [1][2]. Rules are stored in KB in the form of relationship of diagnosis and treatment. And an interpreter makes a decision for supporting procedures against diagnoses. This knowledge base will grow as new relationships between procedures and diagnoses have been made by DSS engine. These rules have been developed by the combination of LCD/ NCD data [11] and past medical history and then stored in knowledge base. Rules have been represented in the form of relationship between ICDs and their related CPTs and then stored in the database.

A Decision Support System (DSS) can support business and organizational decision-making activities by providing an interactive software system to help decision makers bring together helpful information through raw facts and figures, data in the form of documents, domain knowledge, or business entities to spot and provide solutions to problems and for making appropriate decisions. In the current EMR Symptoms are related to diverse test results and past medical history of the patient which then fallout into diagnosis (DX Codes or ICDs). In relation with the ICDs, medical practitioners suggest treatments in the form of CPT(s) on the medical bill or medical claim. Payment(s) are made in relation with those functional CPTs by the insurance companies [3]. For example CPT codes 0001F, 90692, 90691 and DX codes 002.0, 003.22, 009.2, 787.1, 428.9 are related to each other.

3. Architecture of the DSS

Electronic medical record is a computerized medical record for the storage, retrieval and modification of patient's record. EMR maintains Patients record and their medical claims and RBSE (Rule Based system Engine) is being triggered after saving of each claim. Rule based system is an Artificial Intelligence Technique. Medical billing related rules have been applied on claims by rule based system in order to minimize billing errors [2] [8]. Basically three major software applications have been used for maintaining medical records a) Billing Software, b) Web Application and c) EMR. Data that has been entered through multiple EMRs have been stored into client databases. Each EMR has its own client database. Sync client is a software application that replicates the data from client's databases to Server DB1 and Sync-Server is a server side application which manages the overall data replication. Server DB2 is another database server which manages the data entered through Billing software and Web application. Data has also been replicated between Server DB1 and Server DB2 for data consistency. Decision support system is embedded in between EMR and RBSE so that practitioners can see the recommended procedures against selected diagnoses. Rule Based System Engine (RBSE) [2] manages the rules that have been applied on medical claims. It gets all the rules applicable for a certain claim and stored them in working memory. Rules have been developed in the form of SQL Queries and RBSE get these queries or rules from working memory and then execute them one by one. The Fig. 2 describes the overall architecture of Decision Support System.

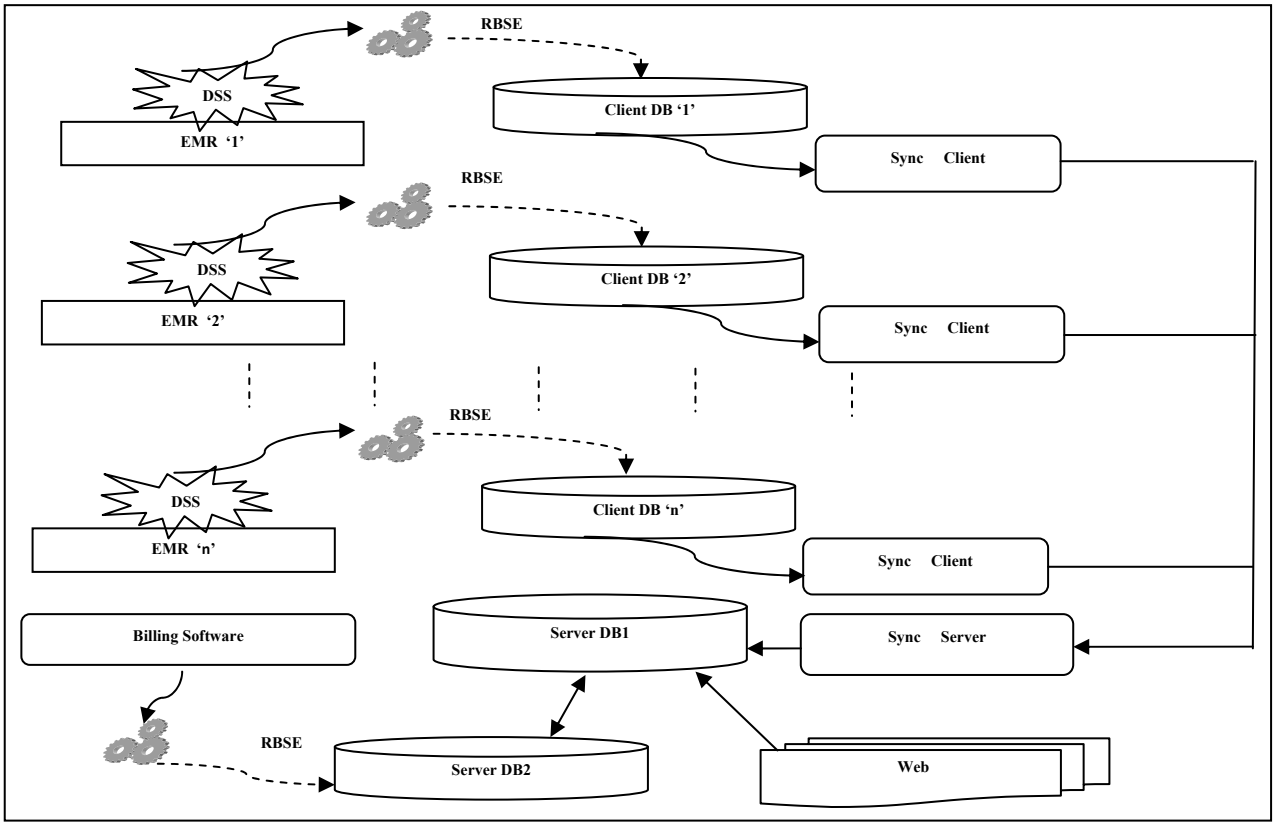

Fig. 2: Decision Support System Architecture

4. DSS Engine Design

In the proposed design of DSS, Current claim of a patient acts as a data acquisition stage and considered as a frame which then compares itself with all paid claims of a patient Objects. Candidate cases will be generated on the basis of these comparisons and Discriminatory, Strong Support, Supporting and Exclusionary actions. And in the last based on the Diagnosis, decisions or treatment actions will be made. This design shown in Fig. 3 has been a little modification of POEMS design as mentioned by Sawar, M. J. [7]. Patients past medical history in terms of claims would be retrieved and on the basis of which candidate cases will be generated. And finally decisions will be made on an account of four cases i.e. Discriminatory, Strong Support, Supporting and Exclusionary. In this case decisions will be made as a relationship of procedure codes and diagnosis codes.

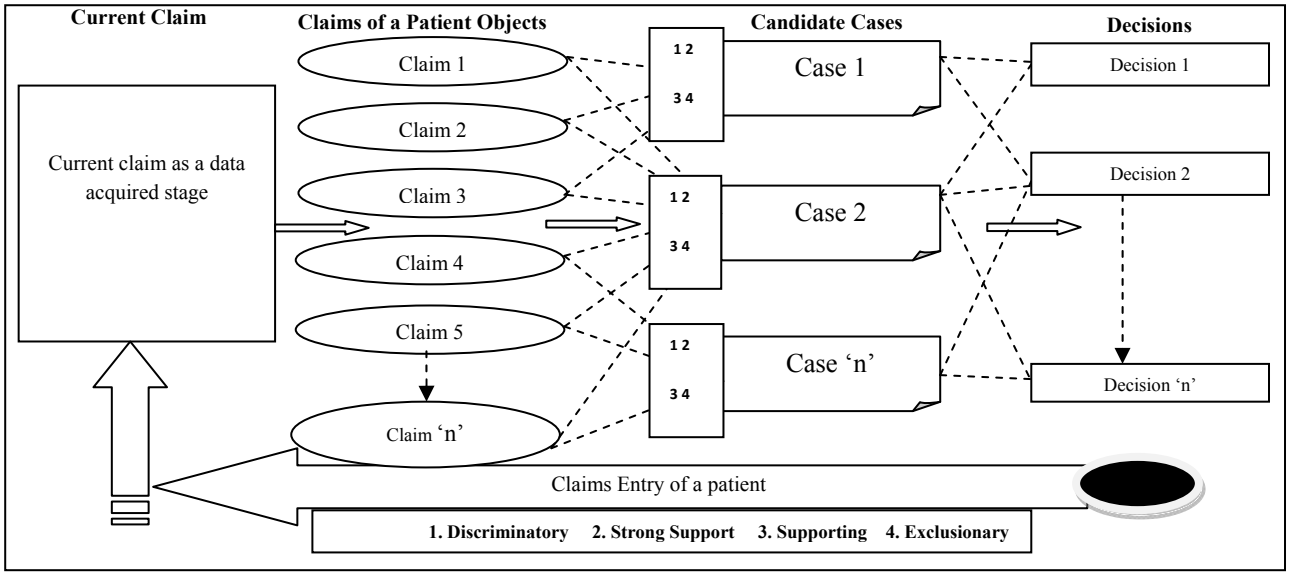

Fig. 3: Decision Support System Design

As per Fig. 4 the system gets the diagnosis selected by doctor in EMR. After the selection diagnosis will be stored in a Working Memory one. The DSS engine compares these diagnoses against treatments from past history of a patient. The data will be stored in knowledge base if available and in case of unavailability it will go through provider's specialty wise. The engine gets all the relationship of procedures and diagnosis from knowledge base and then stores into Working Memory two. Decision will be made on the basis of the data of working memory two and LCD/NCD medical necessity data [11]. In the final stage an appropriate diagnosis with their relevant procedures are ready for providers in EMR as recommendation. The Past history can be determined followed by the proposed DSS is as follows:

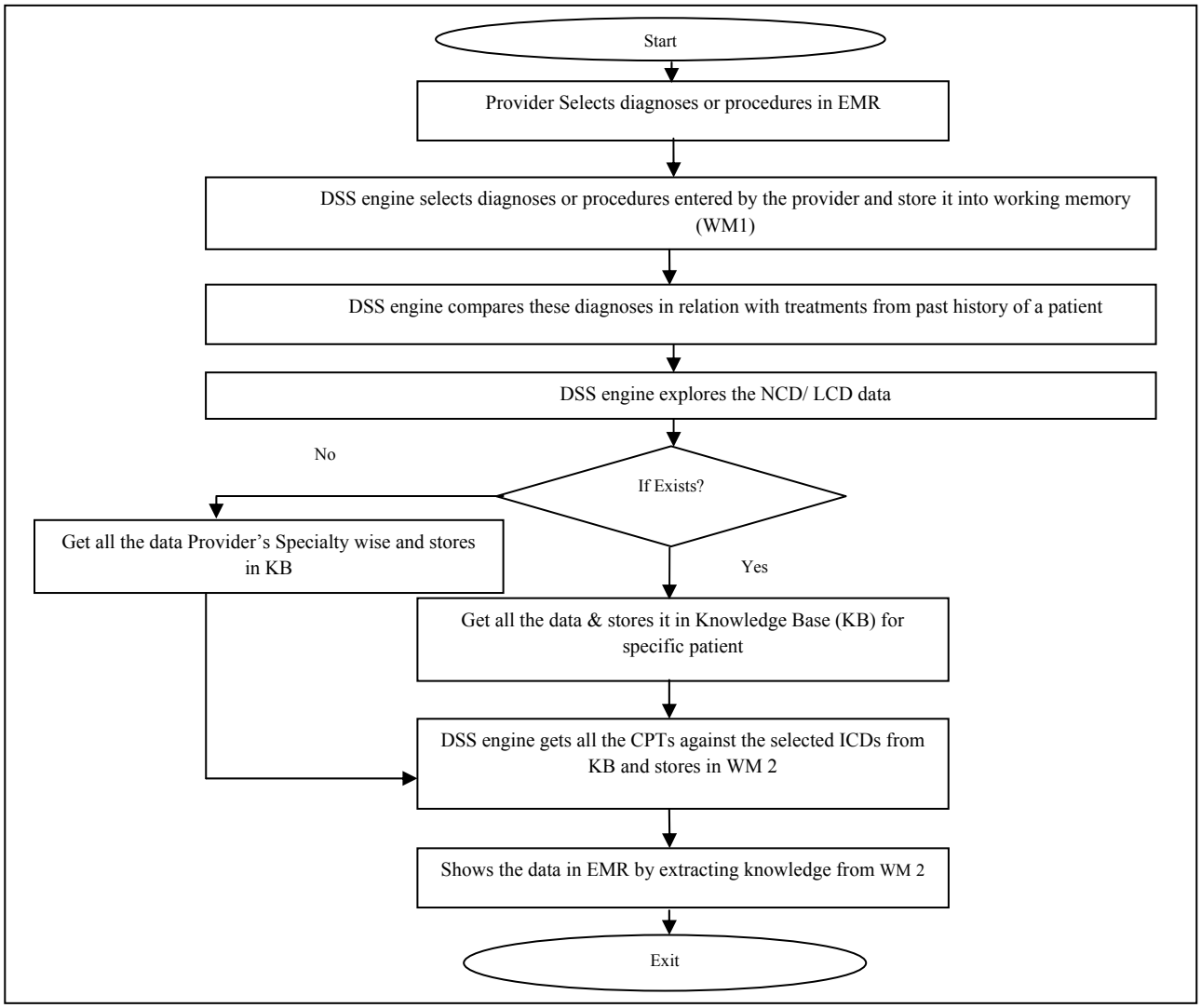

Fig. 4: Decision Support System Engine

Mathematical proof of procedure code and diagnosis code has been mentioned below.

Given Data
DS = Doctors Specialty, PMH = Past Medical History, PC = Procedure Code, DC= Diagnosis Code
NL = LCD/NCD (Universal Medical Necessity Data)
Hypothesis
$x \in (PMH) \ V \ (NL) \ V \ (DS)$ where x = DC or x= PC, $x \in NL$
Proof By Contradiction
Suppose that $\neg (x \in ((PMH) \ V \ (NL) \ V \ (DS)))$
Then $x \notin ((PMH) \wedge (NL) \wedge (DS))$
$x \notin PMH$ (x may not be in PMH)
$x \notin DS$ (x may not be in DS)
But x must be in NL as provided in hypothesis
$\therefore \ x \in NL$
This is a contradiction. Therefore $x \in (PMH) \ V \ (NL) \ V \ (DS)$ Q.E.D

5. Experimental Results with Comparison

Test 1: Percentage CPTs and ICDs of total 994 batches of claims based upon their matching with the current DSS is shown below in the form of Bar Chart in Table 1 and Fig. 5. DSS has suggested accurate 63.82% of CPTs and 95.81% of ICDs in relation with actual existence and accurate relationship of ICDs and CPTs in 994 claims. These claims have total 246 CPTs and 501 ICDs, on the other hand DSS suggested 157 CPTs in relation with 480 ICDs which means that 157 is the 63.82% of 246 and 480 is the 95.81% of 501.

Table 1: Percentage of CPTs and ICDs of Batch of Claims I

Total Claims	994	
	Count	
	CPTs	**DXs or ICDs**
Original claims	246	501
DSS	157	480
Accuracy in Percentage	63.82%	95.81%

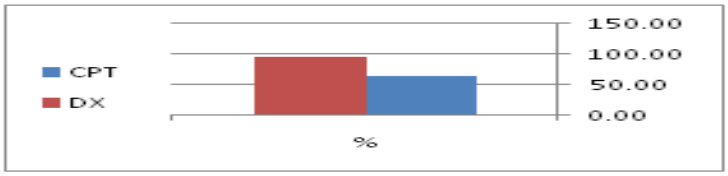

Fig. 5: Bar Chart of Percentage of CPTs and ICDs of Batch of Claims I

Test 2: Percentage CPTs and ICDs of total 54066 batches of claims based upon their matching with the current DSS is shown below in the form of Bar Chart in Table 2 and Fig. 6.DSS has suggested accurate 42.92% of CPTs and 92.6% of ICDs in relation with actual existence and accurate relationship of ICDs and CPTs in 54066 claims. These claims have total 1356 CPTs and 2998 ICDs, on the other hand DSS suggested 582 CPTs in relation with 2776 ICDs which means that 582 is the 42.92% of 1356 and 2776 is the 92.6% of 2998.

Table 2: Percentage of CPTs and ICDs of Batch of Claims II

Total Claims	54066	
	Count	
	CPTs	**DXs or ICDs**
Original claims	1356	2998
DSS	582	2776
Accuracy in Percentage	42.92%	92.6%

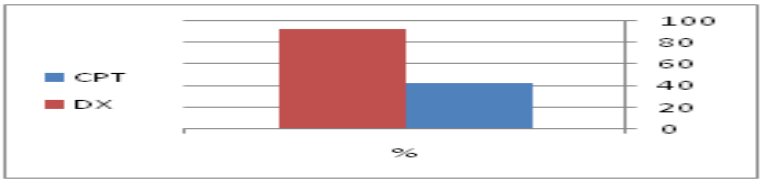

Fig. 6: Bar Chart of Percentage of CPTs and ICDs of Batch of Claims II

6. Discussion and Conclusion

The system developed in this research is a decision support system in which certain rules are working in the form of procedures and diagnosis relationships. The past history of the patients and their claims are helpful for making a hypothesis for decision making process [6]. The providers get benefit from it by increasing productivity, less mistakes by selecting valid procedures, time efficiency and accuracy. And also a knowledge base will be increased as the system works. a) It allows the provider to see the past diagnosis and procedures in the form of CPTs Implemented in Past Claims Against Selected ICDs, Recent Frequent Diseases Dealt By Current Provider, Recent Diseases Dealt By Current Provider For all Patients and For A Specific Patient, Recent Procedures For A Provider, Recent Procedures For A Specific Patient And A Provider. b) It also provides the medical providers to see the medical necessity of the claim as Procedure can be denied by the insurance due to missing supporting diagnoses codes.c) It also provides matching procedures against selected diagnosis and vice versa. The uniqueness of this research is that there is no current EMR that has a decision support system to embed in it but this system has the capability to be embedded in EMR easily and efficiently with reasonable results and acceptability of suggestions by the providers.

7. Acknowledgments

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