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International
Journal
Of Modern Engineering Research (IJMER)

Requirements for Electronic Clinical Record Management Based On the Official Mexican Standard NOM-004-SSA3-2012 and NOM-206-SSA1-2002 with Openemr

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ABSTRACT

Emergency medical care must be a service that is provided with quality, efficiency and equity, therefore, it is necessary that the institutions comply with the minimum requirements for the correct functioning of the services. The clinical record is a tool of great need for the protection of the patient's health. It is a set of information and personal data of the patient in which the physical and mental health and in some cases the social situation of the patient is recorded through the various interventions of the health personnel.

This project documents the analysis of requirements for the development of a data model that manages the information based on the Official Mexican Standard NOM-004-SSA3-2012 and NOM-206-SSA1-2002 that facilitates access to the clinical file in the Emergency Department, with the aim of quickly transferring the updates of the file to other databases.

The purpose of implementing this proposal is to manage information quickly and in a timely manner for the patient and to avoid the loss of information by changing the physical location or the patient's care personnel, thus speeding up medical care.

KEYWORDS: clinical record,conceptual model, Official Mexican Standard

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Date of Submission: 27-04-2018 Date of acceptance: 12-05-2018

I INTRODUCTION

In the administration of hospitals it is of great importance to have the information of a patient updated and available in the different departments related to the medical service: the area of clinical studies, surgeries, drug control, and area of service charges or anesthesiology among others. The ECE (Electronic Clinical Record) is an invaluable source of information in the treatment of any patient who requires medical attention, since the digital nature of these records allows for the implementation of mechanisms that guarantee that the records are always up to date, thus making it easier for physicians to make timely medical decisions based on complete and consistent information. If, in addition, ECEs comply with the health standards established in Mexico, such as the NOM-004-SSA3-2012 standard, the benefits of their use are greater since they allow doctors, hospitals and health agencies to have a reliable source of evidence on the care provided to patients, and in some unfortunate cases they also make it possible to define responsibilities for the medical decisions made. At present, the use of ECE in Mexico is neither generalized nor standardized, so this research addresses the problem of designing a conceptual model based on Mexican health standards and their integration into the EMR (Electronic Medical Record) open source and free distribution systems that could be the basis of the ECE management systems to be used in Mexico.

This document identifies a basic data model in accordance with Mexican health regulations NOM-004-SSA3-2012 and NOM-206-SSA1-2002 that determines the processes of care and the data required of patients,

their diagnosis and medical treatment in the emergency department to facilitate the transfer of information between the different areas of service in a hospital and thus improve the operation of the hospital, improve the quality of service and obtain reliable hospital service statistics.

II PROBLEM STATEMENT

In Mexico, as in most developing countries, medical records are documented on paper, making information management difficult to manage, slow to access and prone to errors due to misinterpretation in the writing or retention of documents. Data published by Pineda, Puente and Garrido [1] indicate that their research identified that only 1 out of 10 surgical clinical records are considered complete under Mexican law and that there is a greater probability of finding incomplete records of patients treated for trauma or gynecological obstetric treatments compared to those treated for abdominal surgery.

In other parts of the world, efforts are being made to apply the personal health paradigm of all institutions sharing digital patient medical information. Samoilovich [2]. This requires the use of protocols and standards that facilitate the interoperability of systems. As a result of these efforts, significant use of EMR systems has been achieved; an example of this increase is the data published by Krishna [3] showing that the number of doctors using these systems has increased by 22.9% from 2001 to 2008 and by 25.7% to 2009. The data shown in Figure 1 show that the use of fully functional systems is also increasing.

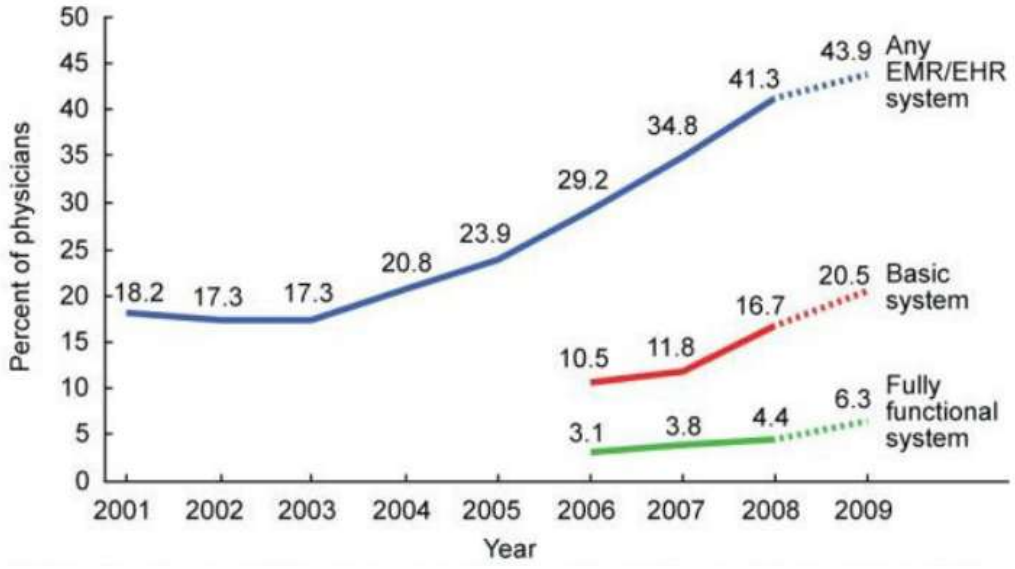

Fig1 Use of EMR- EHR systems in the United States [3]

The efforts to implement EMR and EHR (Electronic Health Record) systems in general in medical practice are not limited to the United States, but have also increased in Spain, Canada and Argentina [4]; this situation contrasts with the situation in Mexico, a country where there is no empirical data to provide figures on the use of these systems and without a policy that integrates technological systems into medical practice in the public sector. In order to take advantage of the benefits that technology can offer in the health sector in Mexico, it is necessary to establish solid and homogeneous bases that facilitate not only the use of clinical records but also allow their exportation to other health institutions based on established standards.

Currently, in the health sector of Mexico, the traditional care paradigm of paper-based care is still being presented, and some private institutions are already using the digital record; what is desirable is to achieve the implementation of the personal health paradigm in all medical institutions in the country, which requires the widespread use of the standards that regulate the use of clinical data. It is evident that in Mexico there is a need for technological applications that support the public health system and allow patients to receive more efficient care [5]. The benefits of using information technologies in the health sector are numerous, but the economic investment needed to develop a single health system at the national level would be enormous, since Mexico currently has more than 120 million inhabitants, for whom a complete digital registry would be necessary, with the expenses that this implies.

The implementation of EMR systems requires the participation of all medical staff, nurses and social workers who need to adapt to the legal norms regarding the use and conservation of records. This process should be promoted by public policies at the national level; as an initial strategy in this research, an electronic medical record data model is proposed, in accordance with Mexican health standards, implemented through an open

access EMR system that can be the basis of an Information System for the emergency department that can be implemented in public institutions as an initial stage of dissemination and use of the ECD. Digital records offer many advantages for medical practice, in addition to facilitating interaction between clinical data collection devices and sensors that monitor the clinical response of patients to assigned treatments.

III BACKGROUND INFORMATION

Research on the use of information technology in the health sector is not new, especially in countries with a greater technological infrastructure; the paradigms of greater frequency of use in EMR systems have been identified, which according to Samoilovich [2] are:

- **Traditional care paradigm**: It is presented when institutions communicate with each other, with different languages or formats and some of them with the patient; in this paradigm there is an electronic, rudimentary and inconsistent health record, since the user must frequently replicate his or her information in different formats, so that data loss is possible.
- **Shared care paradigm**: All health institutions share a language and respect several standards, with this paradigm a specialized electronic record of the patient is obtained, but requires national policies that establish the use of the standards and verify their application.
- **Personal health paradigm**: All institutions can communicate directly with the patient in a standard way, it is characterized by the fact that the personalized health care model is not focused on institutions but on processes.

In addition, a number of standards have been achieved at the international level that allow for the reliable exchange of clinical information. These include the Health Information Portability and Accountability Act (HIPAA), which defines the security and privacy aspects of medical records. the HL7 (Health Level Seven) which defines the message format for the exchange of information to enable interoperability between systems and the ANSI X12 EDI which is the standard defined in the United States for the development and maintenance of Electronic Data Interchange standards.

In Mexico, there are proposals for cloud-based interoperability models through the generation of CDA (Clinical Data Architecture) templates and the use of the HL7 standard [4], and the need to implement the use of ECE in the Mexican health sector has been established; however, these efforts have not yet materialized in the systematization of hospital processes in a generalized manner, so their benefit in public health institutions has not yet been observed.

IV OBJECTIVES

This study aims to analyze the logical requirements of a data model based on the Mexican Official Standards NOM-004-SSA3-2012 and NOM-206-SSA1-2002 and HL7 to describe the necessary adaptations in the OpenEMR system to facilitate the use of ECE.

In the future, new computer modules or subsystems based on Mexican standards may be developed for other medical processes in the different areas of the medical service. The implementation of these bases will facilitate the gradual development of new and larger subsystems that, being based on national norms and international standards, will be able to interact with each other, thus achieving a better health service for Mexicans.

V METHODOLOGY

As a first task to achieve the objectives and based on the techniques of Software Engineering, An analysis was performed of the processes established in the Official Mexican Standards NOM-004-SSA3-2012, on the medical file and the standard NOM-206-SSA1-2002 on the criteria and care in the emergency services and the data involved. The resulting analysis provides the basis for identifying the database needed to implement an application that manages electronic medical records to consult the data of clinical notes and incidents occurring in an emergency medical event.

VI DATA ANALYSIS

In the document written by Codd it is understood that its main concern when designing the Relational Model was the problem of the lack of independence and inconsistency of the data, caused by using both the network model and the hierarchical model in the databases; since these models do not allow an easy modification of the data representation characteristics without causing certain application programs to lose their correct functioning. Its solution is proposed in the Relational Model where the data is described with only its natural structure and allows maximum data independence.

The Relational Model is well explained by its properties, such as: each row is different, which represents n-tuples of an R relationship without a particular order, and each column has a different order. In carrying out the particular analysis, the different entities are identified in accordance with Codd's

recommendations. All of these with their particular attributes are identified through the analysis and requirements that the Mexican standard indicates for the ECE.

In order to identify each of these entities and their relationships, another data analysis is required that complies with the database standard, avoiding redundancy, loss of information and inconsistencies that make the database vulnerable; this analysis is carried out using normal forms.They have been applied since the 1st. Even the highest normal form (HNF), especially for medical notes and medication tables where you see a lot of repetitive general information that can make the database inconsistent.

The first three normal shapes were defined by Edgar F. Codd. One of the objectives of the normalization of a collection of relationships is the Insertions, updates and deletions clear in meaning and therefore easily understandable. Normalization has little to do with pure recovery [5]

The next phase consists of analyzing the services offered by open EMR systems to identify the services that are compatible with the requirements established by the Mexican official standard and with international standards and thus identify the necessary adaptations to be implemented in a free and open-source hospital information system.

For the development of the modeling implementation, it is recommended to use the "Buttom Up" methodology. This methodology according to Masi [6] consists of bringing together different systems that will form a total system. The individual elements are specified in great detail, the components are joined together to form a final system, which is achieved by reaching the upper level. This strategy resembles the "seed" model, in which we start from something small and grow until we reach a finished and complex system.

The large dimensions of a comprehensive information system for the entire health system in Mexico prevents a simple implementation, so it is better to divide the required application into functional modules. For this reason the Bottom Up model is useful because it does not need to have a clear vision of the final state of the project, but to start with it is enough with a particular feature from which the development begins, to later increase functionalities. This is how the small pieces that will later form a great system, made up of sub systems, come together. This methodology has its disadvantages, for example, it takes a lot of intuition to decide the functionality to be given to each module. But this methodology also has other aspects that can be considered negative and that should be considered, among these aspects the following can be emphasized:

- Verification through the process becomes very difficult, almost impossible once you are working with large assemblies. Therefore, a lot of time must be spent on the revision. Additional time is needed to find the error and correct it. Verification through the process becomes very difficult, almost impossible once you are working with large assemblies. Therefore, a lot of time must be spent on the revision. Additional time is needed to find the error and correct it.
- When using a “Bottom Up” design, very little or no scanning is done beforehand, which makes possible improvements in the design evident.
- “Any errors or problems found when assembling the system are more costly to correct, as they involve re-designing the design blocks”. In addition, the processes must be developed in series, which means that the time to finish the design is longer.
- Without reliable communication channels, designers use written or verbal specifications that may be incomplete or poorly formulated, which may be forgotten in the middle of the project. The bad communication generates errors and the separation of blocks allows errors to be found once the project is finished.

This method for product development begins with the design of each of the components, this is denominated as a lower level and is characterized by the fact that the parts are modeled independently (as it advances in the product, it is passed to the subassemblies).

VII RESULTS

The first analysis performed was on the Mexican standards NOM-004-SSA3-2012 and NOM-206-SSA1-2002; using the analytical method, the information of each process was reviewed in an orderly manner, identifying each of the possible entities and the fields referred to in the information to obtain a model of each relationship between the elements to arrive at a functional construction.

In this research all the data was gathered by developing a conceptual model based on the Entity-Relationship model in which the different entities belonging to the database are visualized, as well as some basic concepts that allow the understanding and treatment of the subject. The definition of each entity in the database is proposed based on the requirements and processes described in the standards.

As a result, we have the database as a proposal to manage the patient's information and generate an ECE that allows us to access it at any time and from different databases. This proposal aims to facilitate the updating of a patient's data for medical personnel when providing an emergency service. It is very important

that medical establishments have this information and that it can be shared by different institutions. In accordance with Official Mexican Standard NOM-004-SSA3-2012, which specifies the general information that a patient's medical record must contain, it is described in Table 1 and may be used by any public, social or private sector providing medical care in the country.

Based on the analysis, it is observed that in diagram 1 each attribute of the entity "notes" has its own attributes and therefore cannot be entered as a single domain. This is solved by using four entities for grouping: Notes, Other notes, Reports, General data. Table 1 shows the entities identified with the information that each one must contain according to the standard.

Table 1: Identification of Entities and attributes

Management entity	Attributes
Sector of the establishment	Id, Sector name.
Medical facility	Id, Name of the establishment, Address of the establishment, Name of the institution to which it belongs, Company name, Company name.
Type of service	Id, Service Name.
Medical staff	Id, Professional license, Name, Last name.
Medical specialty	Id, Name of speciality.
Patient	Id, patient's name, paternal surname, maternal surname, sex, age, address, social security number (SSN).
Clinical record	Id,Record type.
Record type	Id, Name of the type of record.
Clinical records	Id, identification card, hereditary history, non-pathological personal history, pathological personal history, current condition, examination by apparatus and systems, physical examination. (Outer habitus, head, neck, chest, abdomen, extremities and genitals, weight, height, blood pressure, heart rate, respiratory rate, temperature.), previous and current results, therapeutics used. (Medication, medical indication, route, dose, periodicity.), diagnosis, medical contract, medical personnel.
catalogue of notes	Id, Name, Short name.
Notes (UN, NE, NT, NI, NPE-O, NPE-A, NP0-Q, NPO-A)	id, mental state, procedure, - reason for referral, type of intervention, therapeutic care, prognosis, patient evaluation, anesthesia type, anesthetic risk, operation plan, operation performed, preoperative diagnosis, postoperative diagnosis, surgical technique, transoperative finding, gauze-compression reporting, incident /accidents, bleeding quantification, post-operative status, surgical biopsy pieces, observations, anesthetic duration, amount applied, clinical status at discharge.
Other notes	id, date of admission, date of discharge, re-entry, reason for discharge, summary of progress, current status, management of stay, outstanding problems, recommendations, risk factors, prognosis, causes of death, report, clinical-diagnostic congruence, diagnostic-therapeutic congruence, diagnostic-therapeutic congruence, quantity, volume, identification number, start date, start time.
Reports	id, procedures performed, pain assessment, risk levels, observations, requested study, clinical trial problem, incidents or accidents, description of results, socioeconomic study, document title, location, authorized act, risks and benefits, medical care authorization, authorizing physician name, witness name, authorized name,full name of the applicant, requesting age, relationship, clinical summary, recommended actions, notified act, injury report, mp agency, epidemiological death report
General information	id, date, time, weight, height, blood pressure, heart rate, respiratory rate, temperature, interrogation summary, reason for service, establishment, receiving establishment, receiving medical personnel, diagnosis, instrumentalists, anaesthesiologists, assistants, circulator.
Medicine	Id, key, name, description, quantity, presentation.
Medication group	Id, group name.

Based on the requirements set out in Table 1, the model ER Figure 1, 2, 3 and 4are designed.

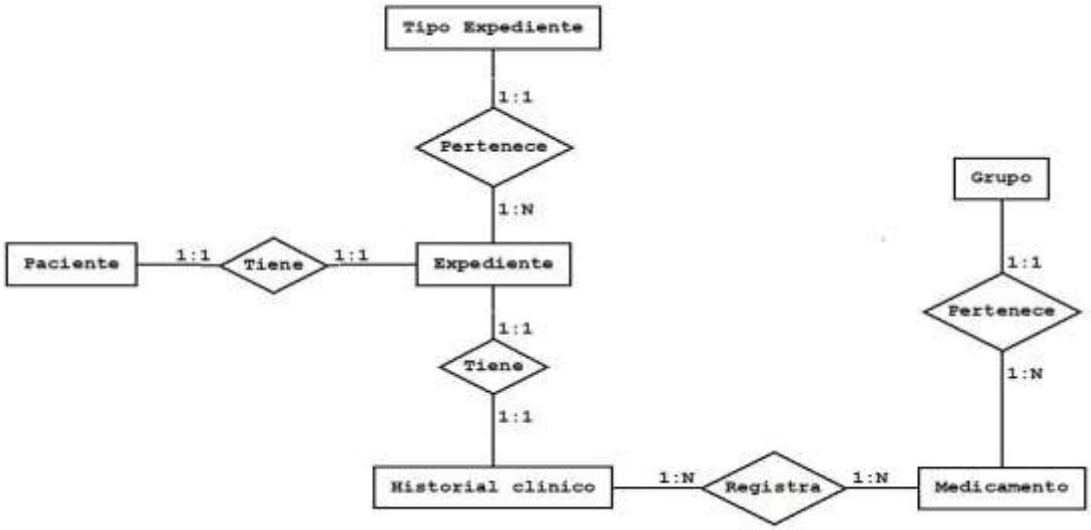

Figure 1: Model ER (Section 1)

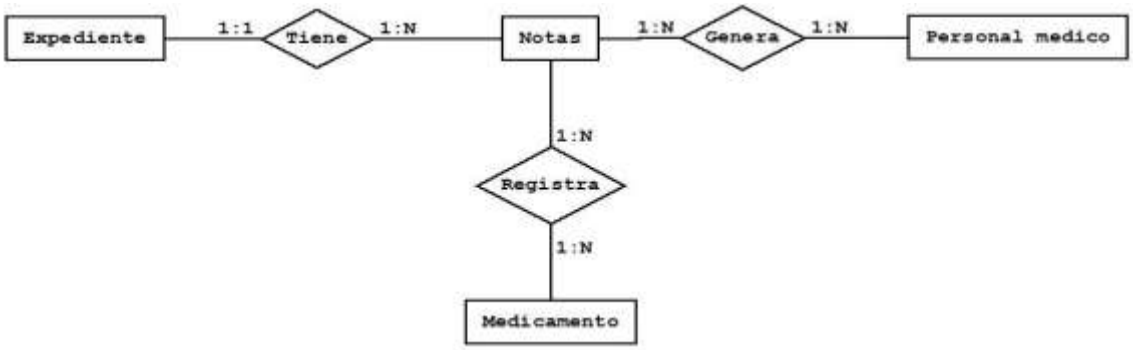

Figure 2Model ER (Section 2)

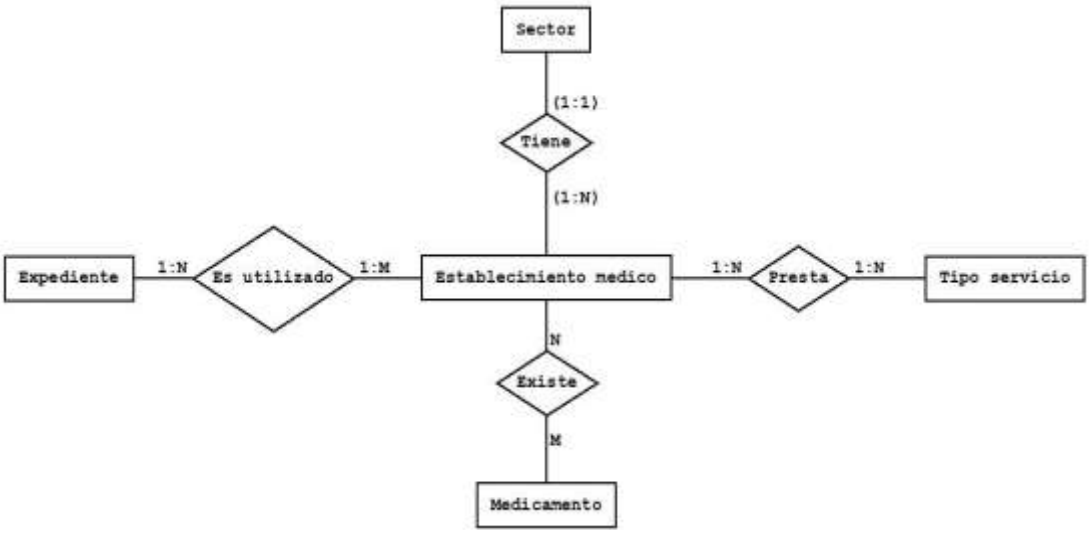

Figure 3Model ER(Section3)

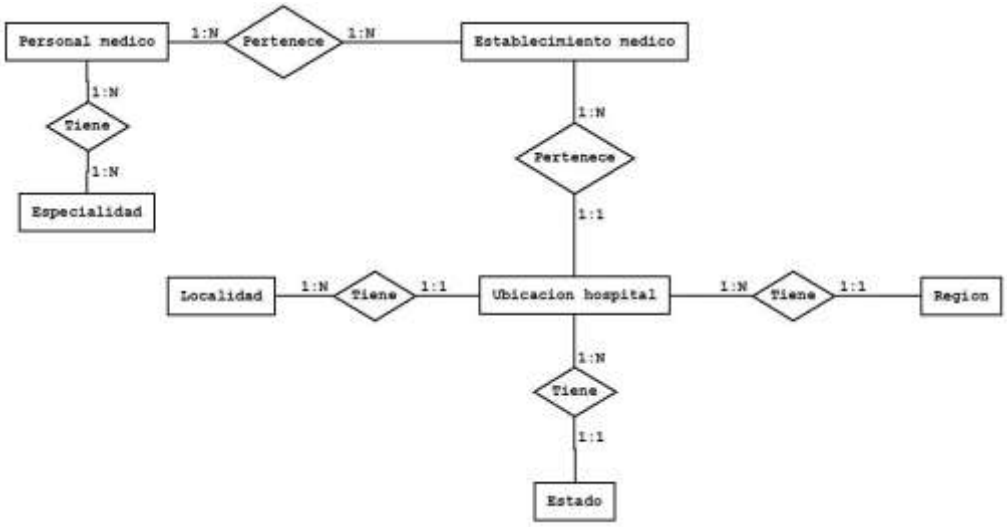

Figure 4Model ER (Section 4)

Normalization.

For the validation of the data and with the purpose of structuring the database allowing its integrity, the normalization method is carried out based on the entity diagram of the figure 1 and figure 2; with the objective of obtaining the relational diagram. The following dependencies are defined as a result of untagging:

FILE_TYPE	FILE_TYPE_ID | FILE_NAME

PATIENT	ID_PATIENT| FIRST NAME | SURNAME_FATHER | SURNAME_MOTHER | AGE | SEX | ADDRESS | NSS

RECORD	ID_EXPEDIENT_RECORD | ID_TYPE_FILE_TE_FK | ID_PATIENT_PA_FK

The clinical history table is related to the file table.

CLINICAL_HISTORY	ID_HISTORICAL_CLINICAL_HISTORY | ID_FILE_HC_FK | IDENTIFICATION_FILE | FAMILY_INHERITANCE | NON_PATHOLOGICAL | PATHOLOGICAL | CURRENT_ILLNESS | INTERROGATION | EXTERNAL_HABITUS| HEAD_DATA | NECK | CHEST | THORAX | ABDOMEN | EXTREMITIES | WEIGHT | SIZE | ARTERIAL_TENSION |HEART_FREQUENCY |BREATHING_FREQUENCY |TEMPERATURE | RESULTS | DIAGNOSIS.

The relationship between the sector and medical establishment tables is created.

SECTOR	ID_SECTOR | NAME

MEDICAL_FACILITY	ID_MEDICAL_ESTABLISHMENT | ID_SECTOR_EM_FK | ID_LOCATION_FK | NAME | ADDRESS | NAME_INSTITUTION | REASON_SOCIAL | DENOMINATION_SOCIAL

A table of the relationship between the medical establishment and the clinical record is created.

TRE_EXPEDIENT_MEDICAL_ESTABLISHMENT	ID_TRE_MEDICAL_STAFF | ID_MEDICAL_ESTABLISHMENT_REE_FK | ID_EXPEDIENT_REE_FK

The relationship between the type of service and the medical facility is created.

SERVICE TYPE	SERVICE_TYPE_ID | NAME

TRE_ SERVICE_TYPE	ID_TRE_ SERVICE_TYPE | **ID**_SERVICE_TYPE **_RTS_FK**| **ID_MEDICAL_ESTABLISHMENT_REE_FK** |

The relationship with the location of the establishment is created and left to scale nationally.

LOCATION	ID_LOCALITY_ID | NAME

STATE	STATE_ID| NAME

REGION	REGION_ID | NAME

HOSPITAL_LOCATION	_LOCATION_ID | **LOCALITY_ID_FK** | **STATE_ID_FK** | **REGION_ID_FK**

Relationship between the medical establishment's board and the medical staff that comprise it.

MEDICAL_STAFF	MEDICAL_STAFF_ID | PROFESSIONAL_LICENSE| NAME | PATERNAL_SURNAME | MATERNAL_SURNAME |

TRE_MEDICAL_ESTABLISHMENT	TRE_MEDICAL_ESTABLISHMENT_ID | MEDICAL_STAFF_ID_REM_FK | MEDICAL_ESTABLISHMENT_ID_REM_FK

The relationship between the medical staff and the specialty they have is created.

ESPECIALIDAD_MEDICA	ID_ESPECIALIDAD_MEDICA | ESPECIALIDAD

TRE_PERSONAL_ESPECIALIDAD	ID_TRE_PERSONAL_ESPECIALIDAD | **ID_PERSONAL_MEDICO_RPE_FK**| ID_ESPECIALIDAD_MEDICA_RPE_FK

The relationship for the medication is created with the medical establishment.

MEDICAMENTO	ID_MEDICAMENTO | ID_GRUPO_MEDICAMENTO_FK | CLAVE | NOMBRE | DESCRIPCION | CANTIDAD | PRESENTACION

TRE_ESTABLECIMIENTO_MEDICAMENTO	ID_TRE_ESTABLECIMIENTO_MEDICAMENTO | **ID_MEDICAMENTO_REM_FK**| **ID_ESTABLECIMIENTO_MEDICO_REM_FK**

The relationship for the medicinal product with the medical establishment is defined.

MEDICAMENTO	ID_MEDICAMENTO | ID_GRUPO_MEDICAMENTO_FK | CLAVE | NOMBRE | DESCRIPCION | CANTIDAD | PRESENTACION

TRE_ESTABLECIMIENTO_MEDICAMENTO	ID_TRE_ESTABLECIMIENTO_MEDICAMENTO | **ID_MEDICAMENTO_REM_FK**| **ID_ESTABLECIMIENTO_MEDICO_REM_FK**

Relationship of the patient's medical history to the medicinal product.

TRE_HISTORIAL_MEDICAMENTO	ID_TRE_HISTORIAL_MEDICAMENTO | **ID_HISTORIAL_CLINICO_RHM_FK**|**ID_MEDICAMENTO_RHM_FK**| VIA | DOSIS | PERIODICIDAD

Relationship of the medication table with the medication group to which it belongs.

GRUPO_MEDICAMENTO	ID_GRUPO_MEDICAMENTO | NOMBRE

For the normalization of the notes, 4 groups are created in which the data can be stored according to the type of note created. A catalog of notes is created to store the types of notes that are required for the clinical record.

CATALOGO_NOTAS	ID_CATALOGO_NOTAS | NOMBRE

The general data table is created in which the data shared by the different note and report tables is obtained, thus avoiding duplication of data.

DATOS_GENERALES_NOTAS	ID_DATOS_GENERALES_NOTAS | FECHA | HORA | PESO | TALLA | TENSION_ARTERIAL | FRECUENCIA_CARDIACA | FRECUENCIA_RESPIRATORIA | TEMPERATURA | RESUMEN_INTERROGATORIO | MOTIVO_ATENCION | ESTABLECIMIENTO | ESTABLECIMIENTO_RECEPTOR | PERSONAL_RECEPTOR | DIAGNOSTICO | INSTRUMENTISTA | ANESTESIOLOGO | AYUDANTE | CIRCULANTE

The Notes table is defined where the relationship with the notes catalogue, the clinical record and the table with general data is identified, thus identifying the type of note to which it belongs and that a record may have N notes of the same type.

NOTA	ID_NOTA | **ID_CATALOGO_NOTAS_NFK**| **ID_EXPEDIENTE_NOTA_FK**| **ID_DATOS_GENERALES_NOTAS_NFK**| ESTADO_MENTAL | DESTINO_PACIENTE | PROCEDIMIENTO |

	MOTIVO_ENVIO | TIPO_INTERVENCION | RIESGO_QUIRURGICO | CUIDADO_TERAPEUTICO | PRONOSTICO | EVALUACION_PACIENTE | TIPO_ANESTESIA | RIESGO_ANESTESICO | PLAN_OPERACION | OPERACION_REALIZADA | DIAGNOSTICO_PREOPERATORIO | DIAGNOSTICO_POSTOPERATORIO | TECNICA_QUIRURGICA | HALLAZGO_TRANS_OPERATORIO | REPORTE_GASAS_COMPRESAS | INCIDENTES_ACCIDENTES | CUANTIFICACION_SANGRADO | ESTADO_POST_QUIRURGICO | PIEZAS_BIOPSIAS_QUIRURGICAS | DURACION_ANESTESICA | CANTIDAD_SANGRE_SOLUCION_APLICADA | ESTADO_CLINICO_EGRESO | OBSERVACIONES

The relationship between the note table and the medication table is defined.

TRE_MEDICAMENTO_NOTA	ID_TRE_MEDICAMENTO_NOTA | **ID_NOTA_RMN_FK**| **ID_MEDICAMENTO_RMN_FK**| INDICACION_MEDICA | VIA | DOSIS | PERIODICIDAD

The relationship between the medical staff and the note table is defined.

TRE_PERSONAL_NOTA	ID_TRE_PERSONAL_NOTA | **ID_NOTA_RPN_FK**| **ID_PERSONAL_MEDICO_RPN_FK**

The table is defined, other scores meeting the same criteria as the "note" table are defined

OTRAS_NOTAS	ID_OTRAS_NOTAS | **ID_CATALOGO_NOTAS_ONFK**|**ID_EXPEDIENTE_ONFK**|**ID_DATOS_GENERALES_NOTAS_ONFK**| FECHA_INGRESO | FECHA_EGRESO | REINGRESO | MOTIVO_EGRESO | RESUMEN_EVOLUCION | ESTADO_ACTUAL | MANEJO_ESTANCIA | PROBLEMAS_PENDIENTES | RECOMENDACIONES | FACTORES_RIESGO | PRONOSTICO | CAUSA_MUERTE | REPORTE | CONGRUENCIA_CLINICO_DIAGNOSTICO | CONGRUENCIA_DIAGNOSTICO_TERAPEUTICO | CONGRUENCIA_DIAGNOSTICO_PRONOSTICO | CANTIDAD | VOLUMEN | NUMERO_IDENTIFICACION | FECHA_INICIO | HORA_INICIO | FECHA_FIN | HORA_FIN | TIPO_REACCION | MANJO_ESTANCIA | PROCEDIMIENTO_INVESTIGACION

The relationship of the other notes table to the medication table is defined.

TRE_MEDICAMENTO_OTRAS_NOTAS	ID_TRE_MEDICAMENTO_NOTA | **ID_NOTA_RMN_FK**| **ID_MEDICAMENTO_RMN_FK**| INDICACION_MEDICA | VIA | DOSIS | PERIODICIDAD

The relationship between the other notes table and the personal medical table is defined.

TRE_PERSONAL_OTRAS_NOTAS	ID_TRE_PERSONAL_NOTA | **ID_NOTA_RPN_FK**| **ID_PERSONAL_MEDICO_RPN_FK**

A report table is defined that indicates other types of information that the patient must have in his or her clinical record.

REPORTE	ID_REPORTE | **ID_CATALOGO_NOTAS_RFK**| **ID_EXPEDIENTE_RFK**| **ID_DATOS_GENERALES_NOTAS_RFK**| PROCEDIMIENTO_REALIZADO | VALORACION_DOLOR | NIVEL_RIESGO | ESTUDIO_SOLICITADO | PROBLEMA_CLINICO_ESTUDIO | INCIDENTE_ACCIDENTE | DESCRIPCION_RESULTADO | ESTUDIO_SOCIOECONOMICO | TITULO_DOCUMENTO | ACTO_AUTORIZADO | RIESGO_BENEFICIO | AUTORIZACION_ATENCION_MEDICA | NOMBRE_AUTORIZADOR | NOMBRE_TESTIGO | NOMBRE_AUTORIZADO | NOMBRE_SOLICITANTE | EDAD_SOLICITANTE | PARENTESCO | RESUMEN_CLINICO | MEDIDAS_RECOMENDADAS | ACTO_NOTIFICADO | REPORTE_LESIONES | AGENCIA_MP | REPORTE_MUERTE_EPIDEMIOLOGICA | OBSERVACION | LUGAR

The relationship between the reporting table and the medication table is defined.

TRE_MEDICAMENTO_REPORTES	ID_TRE_MEDICAMENTO_NOTA | **ID_NOTA_RMN_FK**| **ID_MEDICAMENTO_RMN_FK**| INDICACION_MEDICA | VIA | DOSIS | PERIODICIDAD

The relationship between the report table and the personal medical table is defined.

TRE_PERSONAL_REPORTES	ID_TRE_PERSONAL_NOTA | **ID_NOTA_RPN_FK**| **ID_PERSONAL_MEDICO_RPN_FK**

The number in bytes needed for the complete record of patient care is 20175 bytes equivalent to 19.7 megabytes, the distribution of the requirement by ratio can be analyzed in table 2.

Table 2*Storage analysis.*

Relationship on the Data Base	Bytes
1. FILE_TYPE	55
2. CATALOGUE_NOTES	50
3. GENERAL_NOTES_DATA	1435
4. MEDICAL_SPECIALTY	210

5. MEDICAL_ESTABLISHMENT	769
6. STATE	105
7. FILE	12
8. MEDICATION_GROUP	55
9. CLINICAL_HISTORY	3347
10.LOCATION	105
11.MEDICATION	152
12.NOTE	4516
13.OTHER_NOTES	2604
14.PATIENT	425
15.MEDICAL_STAFF	146
16.REGION	105
17.REPORT	4342
18.SECTOR	50
19.SERVICE_TYPE	80
20.TRE_MEDICATION_ESTABLISHMENT	12
21.TRE_MEDICAL_ESTABLISHMENT	12
22.TRE_EXPEDIENT_MEDICAL_ESTABLISHMENT	12
23.TRE_HISTORIAL_MEDICAMENTO	375
24.TRE_MEDICATION_NOTE	375
25.TRE_MEDICATION_OTHERS_NOTES	375
26.TRE_MEDICATION_REPORTS	375
27.TRE_STAFF_SPECIALTY	12
28.TRE_STAFF_NOTE	12
29.TRE_STAFF_OTHER_NOTES	12
30.TRE_STAFF_REPORTS	12
31.TRE_SERVICE_TYPE	12
32.HOSPITAL_LOCATION	16
Grand total 32 tables	20175 bytes = 19.7 MB

The emergency department is the area with the highest number of hospital service requests; INEGI statistics for 2016 show that in Mexico there were 360,051 road traffic accidents in urban and suburban areas; 235,998 road traffic accidents due to vehicle collisions in urban and suburban areas and 13,362 road traffic accidents due to pedestrian collisions in urban and suburban areas [7] other types of accidents such as fires, accidents at work or those suffered in the exercise of sport are missing. The Mexican Cruz Roja reports that during 2016 it offered 1,429,000 free ambulance services with the support of 13,213 emergency medical technicians and 2,457 emergency and rescue vehicles throughout the country[8].

If an ECE is required for each person attended and in the event that by accident at least one patient is required to be attended, it is obtained that at least 7165014.9 MB would be required to record the care of terrestrial traffic accidents in urban and suburban areas; 4696360.2 MB to record land traffic accidents due to vehicle collisions in urban and suburban areas and 265903.8 MB to record land traffic accidents due to pedestrian collisions in urban and suburban areas. In in terms of Giga bytes it would be 6997.084863, 4586.289258 and 259.6716797 respectively and in terabytes 6.764416409, 4.478798103 and 0.253585625 respectively.

These amounts are not very large but different states have different needs, so a decentralized model would be recommended in which each general hospital in a zone or institution with a medical emergency area would have the necessary resources to keep its records. Rules could also be established regarding the retention of such records to store only such records as may be necessary based on criteria such as need for follow-up, severity of injuries or legal situations; such records could then be retained for some time as recommended by physicians and lawyers. National statistics can be a source of information regarding the needs of each State of the Republic, since, as shown in Fig4, each State has different needs; for example, accidents are much more frequent in States such as Nuevo León, Chihuahua and Jalisco, which all have more than 30,000 accidents in a year, while in Tabasco, Tlaxcala or Nayarit they do not reach 3,000.

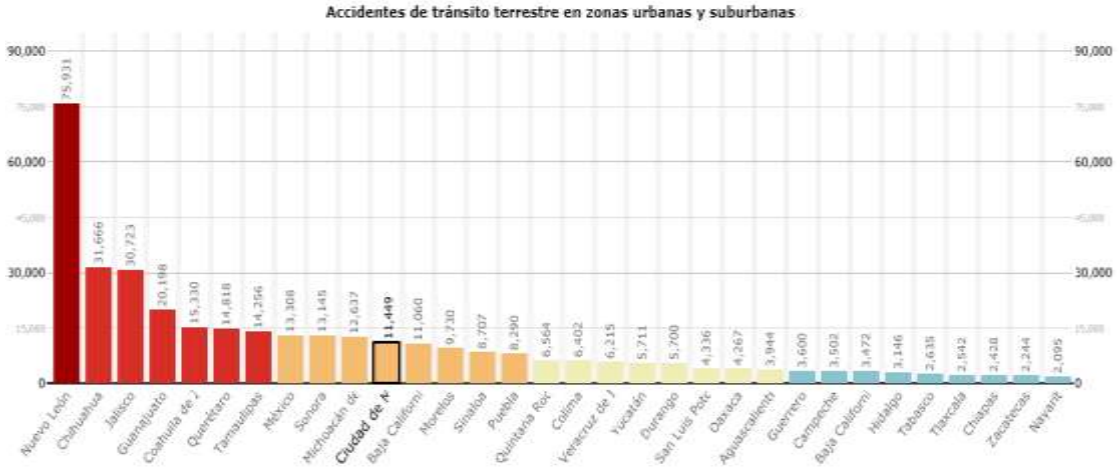

Figure 5Bar graph of Land Traffic Accidents in Urban and Suburban Areas [7]

The requirements in GB per State are estimated by adding the accidents recorded in 2016 is multiplied by 19.7 which is the MB requirement for each ECE in the event that at least one patient is treated in the traffic accident; it is divided by 1024 to obtain the required number of GB and increased by 25% considering a clearance for the recording of other less frequent accidents, the need to record more than one patient or for the possible growth of accidents, the results are shown in figure 5. The quantity in Terabytes is obtained by dividing by 1024. The national requirement with a 25 percent increase is 14,0136,806 terabytes if we consider that Mexico has at least 704 hospitals of the Ministry of Health at the national level and that it is feasible to allocate the storage required for emergency registration through the ECE.

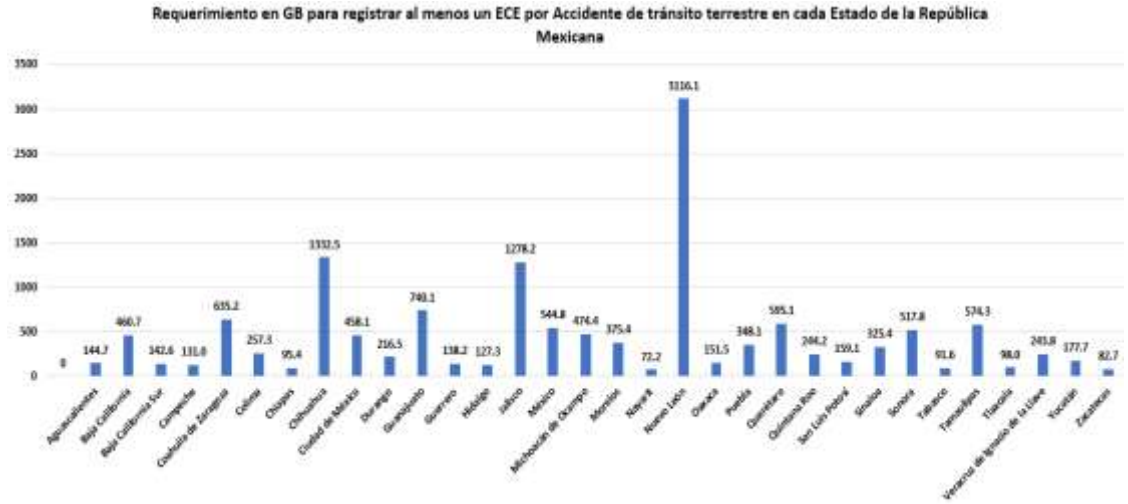

Figure 6: Requirement in GB to register an ECE by accident in the states of the Mexican Republic (own elaboration)

OpenEMR System

Open EMR is an open source project developed for both Linux and Windows operating systems and is ONC certified with international use for its compliance with international standards for clinical data management and according to Samoilovich[9] not only has a higher user acceptance but offers a development team that gives support and growth to the product. Open EMR provides support for the H7L standard by means of which it can receive messages under this standard sent by different medical devices available in hospitals. This facilitates the automation of monitoring [10]. These characteristics identify it as a relevant product to be selected in a lasting commitment as a support for systems of wide and lasting projection such as health systems at the national level.

The technical properties of Open EMR facilitate its use in public institutions as it works through the Apache server, the MySQL and PHP database manager for the coding of forms, all of these tools with extensive development and maintenance support, which allows the use of Open EMR as an electronic health record solution to be considered feasible.

The objective of a more in-depth analysis would be to identify through re-engineering techniques the possible adjustments necessary to the tables that form the Open EMR system to achieve compliance with Mexican sanitary standards.

The analysis carried out by Osorio [11] on Open EMR allows us to identify in an initial way that the files that must be worked on to adapt them to a customized solution, in this case to be adapted to comply with the Mexican health standards must be:

- The php files that show the interfaces for modifying, viewing or consulting the patient files
- The files in php that allow the visualization, modification or consultation of the patient's data.

Based on the code published from the OpenEMR "database.sql" file on the Git Hub distribution site [12] and MySQL WorkBench version 6.3, 65 tables were obtained, which can be viewed in figure 6.

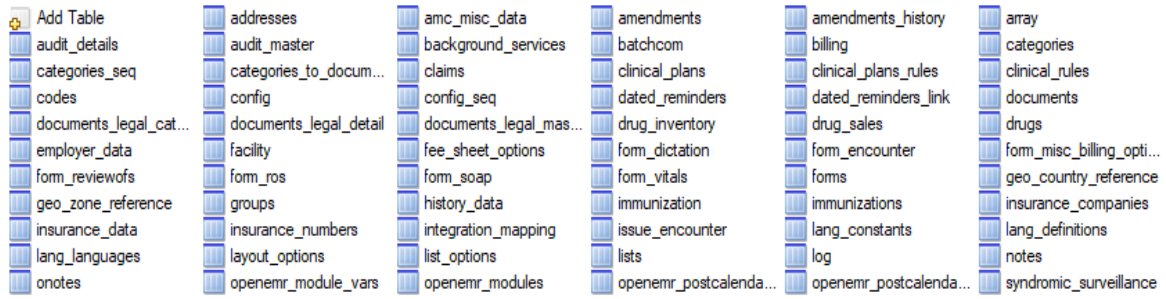

Figure 7: Relations OpenEMR

With the Open EMR fields and tables it is necessary to add tables and fields related to patient care because Open EMR lacks the necessary tables to record medical notes as specified by the Mexican official standard. In addition, OpenEMR'shistory_data table requires new fields to comply with those established in the Mexican Official Standard. Another observation is that there are tables included in Open EMR that support billing and payment for medical services that are not required in the public health sector, although they may be useful in the implementation of Open EMR in private hospitals. It is also noted that it would be appropriate to adapt the OpenEMRinsurance_data tables to record data on the medical filiation of patients.

The Open EMR database has particularities such as geographic zones, related to the United States, so it could be adapted the information of such zones to the localities of our country and add the necessary fields established by the Mexican standard as necessary; the same happens with the data of medicines which are delivered in the public health system in Mexico and are not sold as handled by the Open EMR system.

CONCLUSIONS

The analysis carried out has shown that Mexico has a clear need to introduce information technologies in the management of health services; the health authorities must make decisions that facilitate the implementation of the ECE in public hospitals in accordance with the Mexican Official Standards, but also with the standards established at the international level to facilitate the future scaling up of digital health services and to take advantage of the use of available electronic hospital devices that interact with each other and with the records.

Mexico has several alternatives for implementing an open code EMR system with a high probability of success. A first alternative is to use Open EMR which is a system that complies with the H7L, HIPAA and ANSI X12 EDI standards, there are several documented experiences on the adaptation of the system in specific scenarios such as Universities or other institutions. If that is the case, the implications for the Open EMR system must be analyzed because of the modifications required by Mexican official standards.

Another possibility is to generate a new system based on the data model generated from the Mexican Official Standards to ensure proper and complete compliance with the aspects already regulated by the Ministry of Health, this option should also include compliance with HIPAA, H7L and ANSI X12 EDI standards to achieve scalability of the system.

Physical storage has fallen in cost in recent years so it is increasingly feasible to invest in the technological infrastructure of hospitals to install EMR systems that facilitate the use of ECE in a widespread way to offer Mexicans an efficient and dignified service.

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