UDC 004.9

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MEDICAL INFORMATION SYSTEMS: ANALYSIS OF DEVELOPMENT AND APPLICATION EXPERIENCE

Public Health is one of the main areas, where information technologies are intensively employed. Here we have reviewed and analyzed a number of foreign and native medical information systems (MIS), experience of development and application. It is described features of the system MIS-KhAI developed by use of technology Data Mining and Service-Oriented Architecture.

medical information system, public health, informatization, electronic patient record, reliability

Introduction

In fact, medical informatics has become an integral part of successful medical institution. Many modern hospitals and health care institutions are now well equipped with monitoring and other data collection devices and data is gathered and shared in inter- and intra-hospital information systems. Modern hospitals are rapidly advancing their information systems. What was before an isolated database or a laboratory information system is now integrated in a larger scale (departmental, hospital, or community-based) medical information system.

Extensive amounts of knowledge and data stored in medical databases require the development of specialized tools for storing and accessing of data, data analysis, and effective use of stored knowledge and data. Data is central to the whole clinical development process. Without good clinical data - well organized, easily accessible, thoroughly documented data from well designed trials disparate databases from a variety of systems make it difficult to obtain an overall view of the data.

Clinical data warehouses are complex and time consuming to review a series of patient records however it is one of the efficient data repositories, existing to deliver quality patient care. Data integration tasks of medical data store are challenging scenarios when designing clinical data warehouse architecture. The presented data warehouse is practicable solution to tackle data integration issues and could be adopted by small to large clinical data warehouse applications.

Healthcare providers, hospital administrators and clinical researchers have a need to access various types of clinical and administrative data. The current multiple sources of clinical and administrative data require extensive programming by information system professionals to extract, integrate and massage. This introduces delays in delivering information to those who need it.

IT intrusion in medicine has been in progress all over the world. Since development level, capability and potential differ from country to country, the process of medicine informatization has been flowing indeed unequally. In spite of this, all of the governments, public health services and private enterprises are interested in forcing each of the refining steps.

Development and application of worthwhile medical information system (MIS) is a very complex problem. Several countries from different parts of the world have both positive and negative analysis. However, issues, arisen in the processes of development and/or of application are announced and discussed not so active and so properly as they should be.

Quite adequate and thorough analysis gives Brian Randell in [1]. He touches upon disadvantages of National Health Service of National Programme for IT. A number

of companies have published description of Israel health public system, giving more information about its advantages than about disadvantages though [3-4]. April 10, 2005 James J. Cimino from Department of Biomedical Informatics, Columbia University College of Physicians and Surgeons, presented his work called "Twenty Years of IAIMS: The Columbia University/New York Presbyterian Hospital Clinical Data Repository", where he shared the experience of developing and demonstrates an application of MIS [5].

Goal of this paper is the review and analysis of MIS development and application experience. The structure of the paper is the following: requirements and criteria for comparison of MISs described in section 1; review of predeveloped foreign and native MISs is given in section 2; section 3 describes principles of building and development of MIS-KhAI system; results of comparison of different MISs are analyzed in section 4.

1. Requirements to MISs and criteria for analysis

Every designing system should satisfy definite requirements well considered before system development. More detailed, thorough and close to reality they are, higher is the chance of success while its application. Especially we should pay severe attention to systems that can influence people health and lives. Having analyzed a number of MISs we can single out several main requirements that also meet criteria for analysis in this paper.

Reliability – the ability of a system or component to perform its required functions under stated conditions for a specified period of time.

Modularity – the property of computer programs that measures the extent to which they have been composed out of separate parts called modules. We also mean here horizontal, i.e. functional system scalability.

Complexity – medical systems should not use complex and piled architectures and structures. Only standardized in this area technologies are acceptable. Otherwise, scalability of national programmes would be impossible.

Scalability – whether system is scalable vertically that means can it be enlarged not only within one hospital, but could be realized on interhospital level.

Safety – the condition of being protected against physical, social, or other types or consequences of failure, damage, error, accidents, harm or any other event which could be considered non-desirable. Safe system is being protected from the event or from exposure to something that causes health or economical losses.

Security – this criterion is particularly important for critical systems, because insecure data could give rise to confidential, legal and even political problems.

Usability – one of the main application problems, strange as it may seem, is how easy exactly medics but not IT specialists can employ the system.

2. Review of existed MISs

Great Britain NHS. Britain organization of National Health Service consists of 30.000 surgical departments from almost 300 hospitals. The purpose of automation in the nearest 10 years is the realization of access possibility to patient records and other similar information.

It covers more than 90 thousand employees. Since a «reception» concluding out-patient practicing doctors - all of them must will have an access to this system with the proper access rights (according to their position and qualification) [1-2].

Principal emphasis in creation of this system has been done on an electronic patient record as such, and the questions of safety and access speed to information remained not touched. It resulted arising a number of problems and different potential decisions, for example, smart cards application. But such decision here turned out not suitable and not reasonable, because entry speed in system/registration of new patient took from 60 to 90 seconds, and when it concerns people's life – it's too much time.

Germany National e-health programme. German national IT project of health protection links 2200 hospitals, 100.000 departments, 21.000 pharmaceutical organizations, 200 public health companies.

Unlike other European countries Germany decided to begin with providing of safety and presently it is engaged in setting of infrastructure smart cards. Technically, Patients will be also supplied EPR «Gesundheitskarte». Doctors and pharmaceutists will have an access to patient information. Medical personnel will also have to use smart cards – «Health professional cards» for access to EPR and other similar records information. Now there are 10,000 patients in every region of the pilot program.

Israel Clalit System. The Israel system of Clalit can boast a bit large achievements in this area. At present it serves 3,7 million persons, is one of the most progressive organizations of public health, unites 14 hospitals, more than 1200 clinics, hundreds of pharmaceutical organizations and great number of medical centers. There are more then 30,000 employees.

Initially a network was built on 2000 servers and more than 25,000 work stations which are supported by 27 independent IT parts. But it was decided that such system and infrastructure can no more satisfy all of necessities of organization of such scale. Problems with a data throughput and lack of resources for storage growing amount of information began to appear. It was determinated to centralize and unite technical and human resources, to allow users easily to participate, lead and support medical economic and informative operations. Existent distributed architectural model and 2 thousand servers have to be replaced by centralized, high-performance Unisys Enterprise Server ES 7.000 on a cluster platform which retains almost 3 Tb of information today.

It was also decided to specify requirements and hardly formulate them. During the performance of this objective it was decided to use web-oriented tools.

The system of BINA, based on Proclarity Analytics Platform and Microsoft SQL Server 2000 Analysis Services, was created, it works on Unisys ES 7.000.

Optimizing the peak of the productivity of DB Microsoft SQL Server, the decision of ES 7.000 and Proclarity realizes web-oriented high-speed queries and analyses the great number of medical and business information. Proclarity required only a few seconds for working with applications, while previous one needed 30 minutes.

For 12 months of work BINA could boast of 500 authorized users (including 100 managers from the staff of Clalit) and weekly activity in 2,700 visits [3-4].

University of Virginia Clinical Data Repository. The Clinical Data Repository (CDR) is a data warehouse managed by the Clinical Informatics Division of the Department of Public Health Sciences that contains information about patients seen at the University of Virginia Health System. It provides researchers, clinicians, and students with direct access to detailed, flexible and rapid retrospective views of de-identified clinical and financial patient data [5].

The CDR contains more than ten years of data about UVa inpatients and outpatients. Over 720,000 patients are included. Patient and provider identifiers are disguised or omitted to protect patient confidentiality and privacy. Data, drawn from multiple UVa clinical and administrative patient information systems as well as the Virginia Department of Health, include patient demographics; in-patient, out-patient visit details; diagnoses and procedures; laboratory results; inpatient medications; attending physician(s); payers, costs and charges, reimbursement and death certificate information.

The system can be used to:

– define a patient population for a retrospective research study or for a clinical trial;

– save populations over time and share them with other authorized users;

– retrieve pilot data for grant applications and exploratory analyses;

– look at your own practice patterns, e.g. numbers and kinds of patients seen, diagnosis/procedure mix, financial information;

– identify quality improvement opportunities;

– explore UVa experience to provide information for teaching students/residents or to inform your own practice.

Informatization of Smolenskiy Region Public Health. Regional target programme “Informatization of Smolenskiy region public health in 2003” was approved by

Smolenskiy region administration on 07.04.2003 № 75 [6]. Cardinal programme tasks were penetration of new information technologies into health service institutions activity and creation of single health service system information-analytical net. Main areas of Public Health System informatization are:

– monitoring of processes that are connected with population health conditions;

– telemedicine technologies implementation into practical Public Health;

– region interdepartmental information system integration into the single information space;

– upgrading of human resources and accounting automatization;

– providing of information safety and security;

– system of quality and affectivity assessment of rendering first aid development;

– and some others.

To make the single information space within public health institutions local computer networks are used. Regional medical information network is included into administration regional INTRANET for information exchanging, interconnection and obtaining of required normative legal and social-economic information.

Program interface is maximum approached to traditional paper office work system.

Kirov regional hospital. Having analyzed automated management experience of **Kirov regional hospital**, we can note that it is also a multisectoral establishment. There are 22 clinical and 17 auxiliary departments in its structure. 7 clinical departments of the Kirov state medical academy are established [7].

Since 2000 hospital has employed an automated medical-diagnostic process control system (author – Prof. V.M. Tavrovskiy). The system can be considered as satisfactory for a number of reasons:

– program using does not require special computer knowledge;

– electronic patient records contains all sections of traditional history which a doctor has used to;

– any information is entered once;

– the system is comfortable, clear, simple and reliable;

– it is organized from modules.

The system consists of doctors workstations set in all clinical departments of software complex «Hospital Management».

Since January, 1, 2003 the hospital has fully switched over to the electronic patient records. However, passing to information is carried out not only by network but also by diskettes, that is not so effective in our modern technologies century.

EPR allows to form quickly the examination and treatment patient program. For patient status description, for diaries and operations protocols there are hundreds of the prepared templates which are necessary only slightly to edit.

Despite advantages of administrative management, it should be noted a presence of such disadvantage as possibility of every leader to access any patient record.

Kyiv clinical hospital № 12. Kyiv clinical hospital № 12 was chosen a proof-of-concept ground for the information-analytical system the «Electronic hospital» not by chance. At first, this medical establishment is multisectoral and is located in one building that allows working out the multi-faceted decisions [8]. Moreover, this MPE is not allocated in territorial way. This fact has made easier solving a number of questions related to network technologies and collisions. Main conception of project is not a revolutionary replacement of paper to electronic storages, but an evolutional perfection within the existent requirements framework of regulator organs.

This vital problem would substantially accelerate the process of patient examination and decreased the amount of errors and blots, in connection with absence of necessity of the frequent repeated filling of passport information and other records by a doctor.

Leading computer technologies such as Cisco Medical Grade Network, Samsung Electronics Ukraine were called up for helping in realization of this project. The

unique decision of Cisco Medical Grade Network (network of the medical setting) was developed for medical industry by Cisco, including a number of the specialized medical applications. One of the most urgent solutions is one for medical monitoring – Cisco Clinical Connection Suite Patient Monitoring Solution, created in a collaboration with the leading suppliers of medical equipment. It gives doctors urgent access to important information, for example, to the electrocardiograms. It allows medical sisters and doctors to save mobility and at the same time to have a permanent access to critically important information about patients. However, under specific character of medical personnel work application of the standard personal or portable computers is not quite effective. Therefore a company Samsung has offered for a project «The Electronic hospital» innovative solution – ultraportable computers Samsung Q1 and Q1 Ultra.

Kyiv "TherDeb". In 1995 a small program for maintaining electronic patient records was created. The system was quickly evaluated and in 1996-1997 it was upgraded using Borland Delphi. Since then MIS has been upgraded several times and its functionality has also been growing. At present "TherDeb" covers a great number of medical establishment processes from moving to electronic patient records from papers, EPR analysis, laboratory and other departments to different administrative and economic operations.

Despite this, application of this system in one of the non-surgeon hospitals has shown a number of its disadvantages and perhaps further problems to solve for developers: Power data analysis system is more primitive than its developers said.

– system is surgeon-oriented and appears definite functional demand problems for physicians operations;

– although output printed medical documents meet most of paper requirements, electronic patient record interface does not meet a paper one;

– system is intended for local hospital application;

– absence of usable automated anamnesis constructor;

– it is quite complex to use diagnosis constructor;

– no special safe-oriented technologies in system.

In spite of these and other disadvantages MIS "TherDeb" is successfully used in some hospitals.

MIS «Interin». MIS «INTERIN» developers have proposed an HL-X architecture of corporate distributed MIS building, based on a «document» notion. As basic advantages of architecture of HL-X authors mark out scalability and independence from software realization means. These features are key for automation of territorially distributed MPE.

Main parts of the HL-X system are:

– documents depository stores the data portable logical model and formalize information;

– archetypes depository stores portable formalize knowledge – archetypes of documents (concepts, notions);

– HL-X documents server realizes business-logic of MIS.

3. Principles of development of MIS-KhAI System

Proposed system is an integrated data source to facilitate clinical and administrative data analysis. One of the greatest challenges for an organization is to provide the means for anyone, at every level of the organization, to access the accurate and timely data necessary to support effective decision making, research and process improvement. Our product is just such an integrated data warehouse that provides a data resource to any application or anyone that needs it [10].

The aim of the project is to develop a comprehensive service-oriented e-infrastructure facilitating comprehensive data mining explorations in complex, networked computing environments. The infrastructure will provide components and services enabling a platform-independent access, sharing and application of potentially distributed complex data mining workflows and resources, including database and information systems and hardware resources. With the developed system infrastructure scientists, engineers and business analysts and managers will be able to flexibly define and execute their

tasks and workflows to operate data mining resources and tools across multiple domains and optimize usage of the resources in a distributed environment. The development of demonstrators will be driven by real-world applications. This approach will ensure that significant scientific advancement will be made and that the developed technology will eventually be used in production settings in different areas in the private and public sectors.

The goal of the project is also to increase the effectiveness of research activities in health case sector and to increase the productivity of processing of big arrays of medical data.

Repository for case medical histories is going to be one of the project demonstrators. It will be build using data mining techniques for analysis, classification and other tasks of processing the electronic history cases (EHC).

The Clinical Data Repositories (CDRs) are large, usually relational, databases that receive a variety of clinical and administrative data from primary electronic sources. These repositories collect comprehensive data on large patient cohorts, assembled and stored over time, which not only permit these institutions to examine trends in utilization and outcomes, but also to perform sophisticated quality assurance and medical management queries independent from the systems that collect the data (laboratory, management systems, etc.).

CDR provides researchers, clinicians, and students with direct access to detailed, flexible and rapid retrospective views of de-identified clinical and financial patient data. The system provides patient confidentiality and privacy protection. E-signatures are used for physicians authentication.

In that way the system allows to:

- implement the expert system for effective functioning of health care institutions;
- define a patient population for a retrospective research study or for a clinical trial;
- save populations over time and share them with other authorized users;
- look at physicians practice patterns, e.g. numbers and kinds of patients seen, diagnosis/procedure mix, financial information;
- identify quality improvement opportunities;
- explore health care institute to provide information for teaching students/residents or to inform your own practice;
- support historical security logs;
- support storing and processing x-rays images;
- use electronic forms of case histories, laboratory analysis and other forms that are much like current paper forms;
- use e-signatures.

Data, drawn from clinical and administrative patient information systems include:

- patient demographics;
- in-patient, out-patient visit details;
- diagnoses;
- procedures;
- laboratory results;
- in-patient medications;
- attending physician(s).

We want to emphasize that the demonstrator will have the following characteristics:

- unified service-oriented interface for distributed warehouses of electronic history cases;
- data mining techniques for statistical analysis of EPR;
- services for transformation of EPR to different formats;
- services for visualization of analysis results of EPR;
- service for multi-criteria search in EPR warehouses.

4. Results of MIS analysis

Present analysis shows that MIS development and application is a complex process in consequence of problems of information, technical and psychological nature. It concerns even countries that have high producible medical systems of IT embedding for supporting EPR storage and analysis processes.

Negative and positive features of each examined system have been tried to show in a table 1.

Some cells in a table are clear that means further investigations of the system criterion. And other cells has not only negative or positive valuation but +? or –? signs. Here we incline to believe that the criterion is almost + or almost –, but it should be considered more. Signs +– stand for although the criterion was laid in the system, but it has some negative experience, reviews or opinions. As for the system MIS-KhaI it supposed to take into account all above mentioned criteria. This will effect:

– considerable reduction of time and circulation of documents means costs;

– growth of medical information trustworthiness and its storage reliability;

– providing an opportunity of automation of many areas in medicine.

Further investigations are going to concern detailed analysis of mentioned systems, systems assessment by new criteria and further MIS–KhAI development.

Table 1

Foreign and native MISs analysis

MIS Criteria	Foreign MISs					Russian and Ukrainian MISs				
	GB NHS	German NeHP	Israel Clalit	UV CDR	Smolenskii region PH	Kirov RH	Kyiv №12	MIS Interin	Kyiv TherDeb	Kharkiv MIS-KhAI
Reliability	–	+?		+?					–	+
Modularity	+	+	+	+	+	+	+	+	+	+
Scalability	**+–**	**+?**	**+**	**–?**	**+–**	**–**	**–**	**+**	**–**	**+**
Safety	–	+?	+?		+?	–			–	+
Security	–	+	+		+?	–			+–	+
Usability			+?		+	+–		+?	+–	+
Complexity	+		–		–?			–	–	–

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Надійшла до редакції 22.02.2008

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