User Interface in Medical Information Systems – Common Problems and Sustainable Solutions

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Abstract—As the other segments of society, healthcare delivery can be significantly improved having Medical Information Systems (MIS) as part of its IT infrastructure. MIS systems can be described then as one of founding blocks of efficient, well organized and reliable work of healthcare facilities. This is in theory, but in reality there are quite some cases when introduction of MIS downgraded business processes of medical institutions. These cases are usually related to poorly understandable and confusing user interface. This is particularly emphasized in the MIS employment phase, when users are not used to the new applications. Our research has shown that MIS developers have completely different view to the system than the end users. This fact leads towards serious problems during the adoption phase of MIS. Problems escalate when IT professionals try to apply some fancy interface to "improve" functionality of the system, rather than to follow the end- users' habits. Working on a project of developing MIS for Serbian public healthcare, we have tried one opposite approach – to make user interface as much is possible similar to existing documents and follow existing processes and documentation workflows. Having these two design postulates in mind, we managed to give some improvements in MIS development, which have already resulted with users' approval, and extremely reduced time needed for their training.

Index Terms—Electronic Health Record, Medical Information System, user-centered software development, user-interface design approaches.

I. Introduction

D URING last decade of 20th and at the beginning of the 21st century enormous efforts are done in the area of implementing and using modern information systems all over the world. Information system design approaches, architectures, developing methodologies and technologies are constantly improved and upgraded during mentioned period.

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Information system covered all areas of nowadays world and made many business processes more effective than they ever been. Medicine could be just another field of successful implementation of information systems, but this mission turns not be so easy. Adoption of medical information systems (MIS) was a process that failed many times from many different reasons, from to-complicated architecture to user interface that is not sufficient for medical professionals. This paper presents our results related to user-centered approach of development of MIS system user interfaces.

Luckily, today, medical professionals' leading view is that MIS systems became a necessity for healthcare system in modern society. MIS systems offer wide variety of different functionalities related to healthcare delivery process – from simple document management to complex decision support systems. In more developed countries this kind of science has reached advanced stages of researches, such are preoperative risk predictions [1], or biosignal-based systems for different kind of patient's monitoring [2], but in Republic of Serbia we are at the first stages of introducing and developing of MIS systems yet. A lot of healthcare facilities use only a part of MIS, which is related to recording given medical services and consumption of medical materials, and generating reports needed for government's health insurance agency and public healthcare insurance fund ("*Republički zavod za zdravstveno osiguranje*" on Serbian).

In our project (Improvement, integration and collaboration of information systems of medical institutions, TR13015), which is supported by Serbian Ministry of Science and Technological Development, we have tried to develop much wider and comprehensive approach. MIS we have developed is intended to record not only basic information about given medical services (who did it, what was done, and how much does it cost), but all relevant medical information about medical examinations, therapies, treatments, hospitalizations and other documents that make complete medical history of the patient, or shortly, complete Electronic Health Record of the patient (EHR) [3]. Additional advantage of MIS is that such information system in health care greatly accelerates the process of generating the voluminous documentation that follows all the steps done in any of health services. Example of mentioned documentation is reports for other government institutions which are based on the provision of health services, and reports for the management of health institutions themselves. Data access is facilitated and accelerated in the

sense that they can be accessed from multiple locations simultaneously, and not for each episode of treatment to be performed a physical search of impressive archive of these institutions.

However, it was proven around the world that the introduction of wide software systems in health care has its negative side also [4]. MIS users, especially older ones, have deeply established routine in their daily work, and every novelty can be disruptive to them. Also, many doctors literally do not trust to computers. They are not sure if entered data will be really stored. Also, they doubt about privacy of entered data – which will have access, who can use then for which purpose etc.

Medical professionals usually have to deal with several electronic systems during their work (ultra-sound devices, EEG, Roentgen, etc), which are often provided by different manufacturers [4] and having different user-interfaces. In the period of introducing and implementing MIS (which should act integrative system for all the other electronic and computer systems) to health care facilities especially, it can slow down their working process instead of speeding it up. When a problem occurs with using the software tools, to us as developers, it is often the easiest to blame non-IT professional users, but is it only and real reason for such situations? Or maybe a different approach in the design and implementation of systems could contribute that such situations do not occur or be reduced to minimum?

This paper deals with problems that MIS users have or can have with non user-friendly interface. Section two briefly describes these problems in the way we have tried to classify them. The rest of the paper is dedicated to our approach and our solution to this problem, which gained to results. As one set of problems cannot be bound only to MIS users, but is universal, described solutions can be applied to arbitrary information systems, as well.

II. END USERS AND THEIR MAIN PROBLEMS WITH MIS

Users of information systems in health care, beside administration that can be met in every area of one society, are usually doctors and nurses. Administrative staff use IS modules like evidence of employees, financial accounting, accounting earnings, material assets, and similar. EHR modules are used only by doctors and nurses, according to the law of patient's data privacy [5].

In general, in relation to the use of application modules, we can define two main groups of users:

- Users that most of their work spends using only software tools.
- Users who are dedicated to clients (patients) or some other electronic systems, and only part of their work spend using software.

Doctors and nurses belong to the other group of users. Their daily work must be dedicated more to the patients' treatment and less to the information system. Let us consider the fact that they are confronted with several different electronic systems, usually provided by different manufacturers, and in our country entirely never integrated with the information system. Additional difficulty is that they are strongly used to paper evidence in Serbia for many years. Working on the MIS development, on the basis of multiple interviewing medical staff employed at the Ambulatory Health Center of Nis, and the Clinic Center in Nis, (Department of Child Internal Clinic and Clinic of Neurology), we have attempted to categorize their current problems, and issues they could have in working with parts of the medical information system:

- Windows or web forms for inserting and editing data are endless.
- Lack of descriptions and ranges of normal values on the form
- Users find themselves "lost in application". When the functionality of the medical process is such that it demands entry (or choice) of a large amount of data, and more than one windows form is opened, and more than one "save" action is necessary, users after a while don't know where they are, or what they have recorded yet, and what to do next.
- "They lose a patient." If system demands moving patient from one list to another many times during the examination, one wrong mouse click and patient is completely "lost" in the system.
- The layout of tabs on the form is inadequate in terms of monitoring the natural process of entering data in a commonly used scenario.
- Search for right value is slow and endless. Combo boxes contain hundreds or thousands of values; too much of the working time is lost for searching.
- Some data is entered more than one time in the system.
- Too many rows lost because application did not ask the user: "Are you sure…" and the wrong mouse-click were fatal.
- Repeating of the same or similar actions several times in the working time. There are situations when user acts the same many times a day (like injections to the patients) and yet, he or she need to enter the same information every time again, just for different patient, because system demands, and many other.
- Scrolling up/down and scrolling left/right are too frequent.
- Suggested values are not properly spelled (especially in Latin sentences)

III. STEPS TOWARD SOLVING THE PROBLEM

Problems like described are detected not only in Serbia, but in the west Europe countries, as well. According to the researchers of the *Smart Transplantation Project* in *German Research Center for Artificial Intelligence (DFKI),* like it can be found in [4]: "More than 30 staff members of the Department of Hematology and Oncology at the Heidelberg University Clinic participated in an online survey which asked about various areas of application of Information and Communications technologies (ICT) within the hospital. 94%

of those asked responded that IT applications are critical to the daily routine at the clinic and 90% said more than 50% of their work involves the use of computers; 58% even reported more than 75%.

Important criterion for the respondents was not only a timely system response but also that the system be efficient and user friendly. The responses were ambivalent concerning the current state of integration of the IT applications in the daily work routines." Information as listed are not flattered for designers and information system developers at all. Without the strong cooperation of the development team and future users of software systems it is difficult to expect that the project will result in a satisfactory user interface. Our research project and development in this direction gave some results as this paper presents. The concept "From the conversation to the user interface" in the steps shown in Figure 1, resulted in mutual satisfaction of us and our users, both. The third step asks for attention, because it is the step that can save a lot of time to developers in the further designing.

IV. DESIGN OF INTERFACE

Addressing the second and third activity of the diagram shown in Figure 1, we have noticed that the medical staff deals with enormous paperwork. Usually, they need to enter data at least twice – once in patient's paper based health record and in institution's log book. However, they are very used to it, and they know in advance what paper form to fill and how to fill it, like they could do it with their eyes closed. We wanted to help users to improve process of entering data and help them to avoid inserting same data more than once. Critical point here is that medical staff members can be slowed with MIS compared to dealing with paperwork only. Main reason for this potential problem is that MIS users are usually slow-typers, and they need significant amount of time to type (instead of handwrite) different documents. So we came up with the idea that the patient's electronic health record should look the same or very similar to the paper based or the parts that cannot be fully copied should at least have the same layout of fields as in the paper document. Also we offer as-type-complete functionality for all entities that are described with codes and names – diagnoses, medicaments, standard documents, etc.

Instead of adjusting the form interface to the functionality, we have scanned paper documents, and planted them to the windows forms everywhere we could. One example, where it was possible to adjust interface in a great deal to paper, is shown in Figure 2. Figure 2a represents paper patient record that health workers operate dozens of years with. Similarity to the electronic form of the main page of patient record, which is shown in 2b, is obvious. Figure 2a shows front page of paper based patient health record. This record is an envelope consisting of four pages where each page contains some general medical data about patient – immunization statuses, common diseases, chronic diseases, findings on annual medical examinations, main health risks, information on

allergies, etc. Each page is represented by one tab looking exactly as corresponding page. Also, tabs have exactly the same sequence as the sequence of pages inside patient record. In the cases when it was not possible to provide exactly the same design in the electronic forms, we have tried to contain the layout of fields, like shown in Figure 3a and 3b. Here we tried as much is possible to follow paper document.
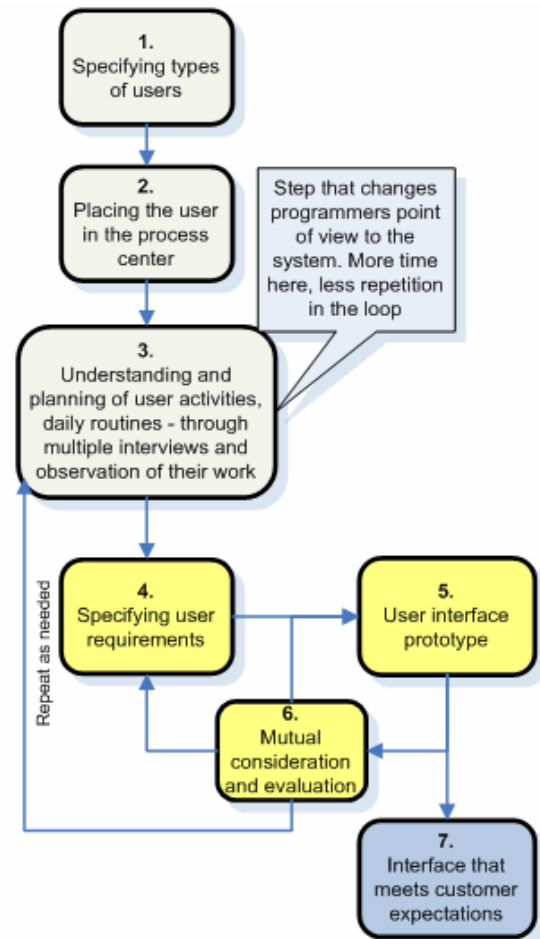

Fig. 1. The interdependence of human-centered user interface activities.

The result of this approach to designing the user interface was more than satisfactory. User's resistance to the new software was minimal, and they needed no explanation of windows forms for EHR. Another important moment in understanding user activities was a job routine and medical documentation workflow. Routine work with software is gained easier if it is similar in different functionality. For this reason we decided to follow the one and the same standard for every man-computer interaction. Unique ways for search data is used everywhere, to enter, read and delete data, etc [6].

After each action the recording of data in the database is provided, according to the research that showed that users often lose control of where they are in the application. Deleting is not permitted to all users, but it is in accordance with privileges. The time (on server) when the item is added is examined whenever someone tries to delete it. Time after which the removal is still allowed on the server is adjustable

[5]. Upon expiration of the time (the time seen as a time in which they can correct random errors) all changes are recorded (the old value, new value, who made changes and when). So the possibility for user to accidentally delete item is minimal.

Fig. 2a. The first page of patient's paper record, for preschool children.

Fig. 2b. The first page of EHR for preschool children.

Another important goal in EHR design phase was not to let user enter arbitrary data, but to choose between offered values whenever it is possible. Classical windows search through controls like combo or list box is exactly what our research showed that users complained to. For example, last catalog of diagnoses (standard MKB10) contains exactly 14193 different diagnoses. General practitioner (GP) has to have all diagnoses available for choosing. Can you imagine popup of 14193 items for choosing the right one? This subject has different approaches among designers worldwide. Some of them use the concept of giving only few dozens of most used diagnoses in the late period [7]. This approach, however, can signal to the doctor what diagnoses or therapy to determine, or what facility for hospitalization to recommend. To avoid that, and to let doctors rely on their own knowledge, but to provide them quick choice of items like diagnoses, drugs, facilities, medical materials, we have developed our own Search component which is applicable to any kind of catalog data.

Fig. 3a. The inner part of paper record, for recording diagnoses, therapies, dates, etc. during the visit.

Fig. 3b. Tab for visits. Double click on every cell opens modal form for recording proper medical data.

Fig. 4a. User typed three characters of the medication code and 11 corensponding medications have appeared for choice.

Fig. 4b. Choosing diagnoses in exactly the same way, only by typing the beggining of its name instead of code.

Starting with a fact that all catalogues are similar as entities, that they usually have the name and some kind of code for every item, we have made searching through 3 attributes (which are configurable). Every catalogue is modeled with a database table. Search component is independent and it links to a table. It addresses database after the third typed character (third is default, but it's configurable), and gather appropriate dataset, which is usually consisted of few dozens or only few items. Filtered items are shown under edit boxes, and user can easily, using mouse or keyboard arrows, choose proper value, or he can keep typing and narrow the selection to one or two items. The examples of searching values through our component are shown in Figures 4a and 4b.

Performing the same search process for every catalogue in all modules, we provided a kind of introduction of user applications in the daily routine and getting used to working with the system quickly. Another important item that we have avoided by this approach, and concerns the efficiency of the system, is the congestion that can occur when hundreds of concurrent users search through the same catalog in the database. Because the filtering is done after the third key typed, dataset that server returns to the client is consisted of ten or twenty records, the traffic in the network is greatly reduced compared to constant loading of entire catalogs.
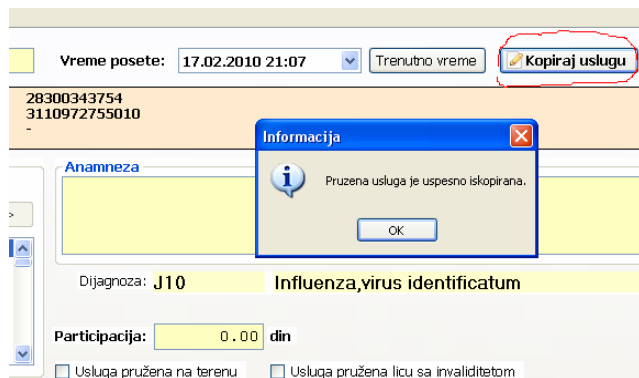

Fig. 5. The possibility of copying data for given service together with medical material, for giving injections.
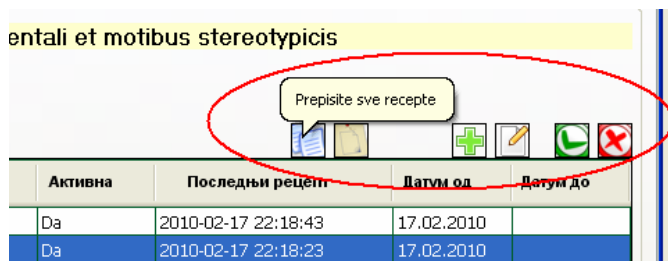

Fig. 6. Accelerated prescription of recipes for chronic patient.

In the choosing doctor module (in Serbia in the last few years, each patient selects his own doctor and make a contract with him), this component is used for the selection of doctors for whom the patient wants to make a statement. Since this function at the Health Center in Nis is made by nurses, they have to perform a search among the hundreds of physicians of this institution. However, with our module and described way of search through catalogs, their work in the recording patient statements proved to be easy and fast, without errors, and what is most important - do not create waiting lines at offices. According to the our research that users complain in the sense of repeating the same actions more time in a day, and having to enter the same data for insurers again, we have provided them *Copying of done actions* through user interface. Figure 5 shows Copy button for recording of given medical service, which is on our country an obligation of every health care facility.

Good example of copying actions is related to the patients with chronic diseases. They (especially older ones) come again and again to get the same or similar therapies from general practitioners. So we have provided our users (in this example only if they are GP) with a possibility to copy prescriptions, if the patient was marked as chronic one. With one mouse click through user interface, therapy is shown in the EHR, and doctor further has 6 different possibilities, provided through 6 buttons in user interface, described as follows from left to right (Figure 6): copy all medications, copy only selected one, add some therapy, change selected item, activate or deactivate selected therapy. Therapy is defined as permanent in the system, and it can be consisted of many medications.

V. CONCLUSION

In most cases medical information systems are charged with a large number of users, hundreds or even thousands of them. It is almost impossible to satisfy the great population like that with user interface in any kind of area. However, health care as a very important feature of a modern society requires fast and reliable systems, considering the fact that one side of systems are live people, with limited response waiting time (babies, old ill people, etc). Sometimes that time is critical, as when it comes to emergency situations. MIS instead of paperwork is a huge change, especially for medical staff with 20 or more years of working experience. It can seriously reduce their working performance, and produce long lines of patients in the waiting rooms, in the beginning phase of using it.

Without cooperation with future users we cannot even imagine a good MIS as a result, since the views are always different from the designers and user's points of view. Brokers in the development of the IS can play a key role in the whole process, if there are some. However, our project has shown so far that much can be done, and designers could easily become agents to themselves, if they strongly respect process of designing user interface as is shown in Figure 1. Interaction with future users should not be a waste of time to the designer in any case. On the contrary, the more time spent in the phase 3 of mentioned process will reduce with the less time spent looping, and users will be more satisfied, and give less resistance to introducing new software.

Three things have proved to be important for designers of medical information systems in our project in the system-user interaction: neutralize the fear of introducing innovation in the work process with having these innovations presented in the user-close way; keep the user in the process of the similar daily routine work that was before the introduction of new system; and enable quick and easy way of using system functions without suggesting the user what is his future step or choice in working with the system. Consistency in the

interface of the module and all forms is necessarily implied. In order to reduce errors it is necessary to reduce the entrance of free text to the minimum, and wherever there is a predefined catalog, user should be given the choice of appropriate values. The smaller count of values for choosing user get, the quicker choice he will make, and the resulting error rate in choosing process will be reduced. Appropriate search component can be a solution to that, like we have shown in previous chapter. The order of fields in the form should follow the established working process, and the design of the form should always have at least one thing that user will recognize at the first human-system contact.

Beside MIS, these recommendations could be applied in any kind of information system designing, with some kind of modifications.

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