

# Quality Assessment of E-Health Solutions in Primary Health Care – Approach Based on User Experience

Damir Kralj

*Ministry of the Interior, PD Karlovac  
Croatia*

## 1. Introduction

The significance of primary health care (PHC) within the overall health care system of the each country is tremendous. PHC provides the first contact between patients and health care system, and keeps the most complete medical records of particular patient which could be used later for different medical secondary purposes. Well organized and computerized PHC significantly improves both the quality of care and contributes to significant savings in treatment. In order to improve the quality of such information systems, it is necessary to introduce a methodology for measuring their actual quality. Our research focuses on the creation of models for assessing the quality of IT solutions, based on users' (doctors') experiences, within the newly introduced primary health care information system in the Republic of Croatia.

The process of implementation of the national e-Health infrastructure in the Croatian public health care system started in 2006 by introduction of the Croatian primary health care information system (PHCIS or CEZIH in Croatian language) (Croatian Institute for Health Insurance [CIHI], 2010). The first areas of the system implementation includes the integration of family doctor's offices (FDO) into a comprehensive system, that includes the integration of various types of FDO specialized solutions with national infrastructure, Croatian Institute for Health Insurance and Public Health Authority. The system is generally tested "in vivo" i.e. in real production conditions and with real patients' data collected in FDO. The central part of the information system was designed by the renowned company, specialized in area of those projects, as a very stable and quality system based on well-defined business processes, legal and semantic rules, and communication and messaging standards such as EN13606 and HL7v3 (Končar & Gvozdanović, 2006). Design of the applications for managing of the electronic healthcare records (EHR) in FDO was left to a number of small IT companies competing on the Croatian market. These applications had to undergo certification process defined by the Ministry of Health and Social Welfare (MHSW). Certification included only the area of communication and basic data exchange with the central part of the system. The concept and functionality of these applications has been left to the manufacturers of these applications (Kralj & Tonković, 2009). With such situation in

place, it seems very difficult to measure the quality and effectiveness of an information system which is in the early stage of development. For these reasons, our motivation was to establish a methodology to quantify and qualify overall quality criteria.

## 2. Methods used in the project

For the purposes of this study, we defined a methodology that consists of eight steps showed on Fig. 1. As we can see, our methodology is based on overview and analysis of domestic papers and foreign projects, studies, standards, initiatives and certification criteria. On these foundations, we constructed our assessment and built assessment tool i.e. questionnaire.

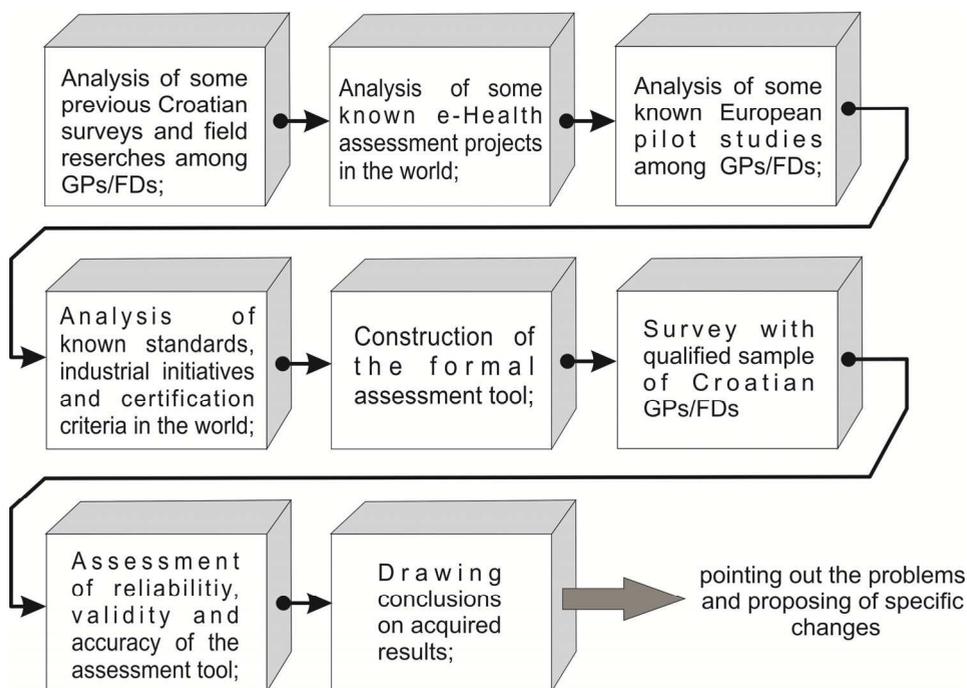


Fig. 1. Preview of used methodology

## 3. Overview of the relevant documents and projects

The basic idea of the formation of such a methodology arises from so-called frameworks for assessing of community readiness for the introduction of e-Health. One of the earliest references is the "Framework for rural and remote readiness in telehealth" that was conducted in 2002 by Canada's advanced research and innovation network CANARIE (CANARIE, 2002). This paper describes the basic assumptions that derive from the theory of change and stages of change. Readiness is defined as a cognitive indicator of actual conditions, with determining the factors that contribute to success and factors affecting the failure of some innovations. The next interesting example can be found in association of the

Aga Khan University in Pakistan and the University of Calgary in Canada (Khoja et al., 2007a). The subject of the project was development of tools for e-Health readiness assessment in developing countries. In this project were proposed methods for validation and reliability testing of the tool for e-Health readiness assessment. The assessment is based on a quantitative presentation of qualitative data. In order to verify the reliability of the tool and to avoid multiple control testing, there was introduced a calculation of the Cronbach's Alpha ( $\alpha$ ) coefficient of correlation for each category of readiness and for all categories combined. A third interesting example is found in the study "e-Health Readiness Framework from Electronic Health Records Perspective" (Li, 2008) conducted on the University of New South Wales in Australia. Research contribution of this study consists of three essential elements: a model of framework, methodology of assessment and evaluation of framework based on criteria and case studies. Our work is taking good reference in some basic analysis from these models. However, some early results have shown that they are not sufficient in Croatian example. More precisely, all the models referenced above are based on an analysis of isolated cases ("in vitro") by gathering the elements to assess the readiness of a small part of health system for the introduction of e-Health concept, while our framework requires experiences assessment in real production ("in vivo") and large scale deployment, which leaves us with highly challenging environment that requires careful assessment and offers less change manoeuvre space. Analysis of the Croatian papers drew our attention to specific problems before (Kern & Polašek, 2007) and shortly after (Kralj & Tonković, 2009) the beginning of implementation of e-health concept. Analysis of worldwide standards such as HL7, EN13606 and DICOM, and initiatives such as Integrating the Healthcare Enterprise (IHE) and EHR-implement, is simply unavoidable. In addition, when creating our methodology, we have also taken into account latest recommendations from European Institute for Health Records (EuroRec) EHR-Q TN project, criteria of The EuroRec EHR Quality Seal Level 1 and Level 2 (EuroRec, 2010), projects and recommendations of the American Office of the National Coordinator for Health Information Technology (ONC) and certification criteria of the Certification Commission for Health Information Technology (CCHIT) (Centers for Medicare and Medicaid Services, 2010), which has lead us to the final readiness assessment model. It should be noted that these American recommendations and criteria resulted in mid-2010 with a set of certification criteria called Meaningful Use of EHR Stage 1, which is a direct consequence of the American Recovery and Reinvestment Act (ARRA) of 2009. The contents of European studies that were conducted by research agencies Empirica (Dobrev et al., 2008) and Health Consumer Powerhouse (Björnberg et al., 2009) were also of great help in the making process of the assessment tool.

#### 4. Construction of the assessment tool

Based on previously mentioned foundations we made a framework for the assessment tool i.e. questionnaire. The framework consists of seven main units. While the first unit contains general questions about the doctor and his/her office, the remaining six units measure major dimensions i.e. categories of experience which our work has identified as needed. As we see in Table 1, these six categories are: basic experience, technological experience, engagement, domain experience, organizational experience and societal experience. Each of these categories is a key performance indicator (KPI) of the current state of implementation of the e-Health concept in the health system as a whole. When designing this framework, we

tried to include the key factors that can describe doctors' problems and attitudes, doctors' involvement in the process of adopting of new technologies, the impact of new technologies on the domain workflow, changes in communication with other health organizations and offices, and, of course, the impact on communication between doctor and patient. In addition, we have tried as much as possible to reduce any overlap between categories i.e. to ensure unambiguity of the categories.

A) BASIC	B) TECHNOLOGICAL	C) ENGAGEMENT
<ul style="list-style-type: none"> <li>• Attitude about use of computers in FDO;</li> <li>• Organization of work on computer support;</li> <li>• Impact assessment of use of computers to work process;</li> <li>• Attitude about basic elements of e-Health.</li> </ul>	<ul style="list-style-type: none"> <li>• Problems with hardware and network support in FDO;</li> <li>• Quality and reliability of EHR applications in FDO;</li> <li>• Readiness of diagnostic equipment for use in e-Health;</li> <li>• Data protection and patient safety.</li> </ul>	<ul style="list-style-type: none"> <li>• Self-assessment of the IT and medical domain knowledge;</li> <li>• FD engagement in process of new system implementation;</li> <li>• Use of EHR for evaluation of doctor's work and research;</li> <li>• Care about the safety and security of the EHR.</li> </ul>
D) DOMAIN	E) ORGANIZATIONAL	F) SOCIETAL
<ul style="list-style-type: none"> <li>• Domain usability and functionality of EHR applications;</li> <li>• Structuring and encoding of information in EHR application;</li> <li>• Implementation of advanced decision support systems;</li> <li>• Monitoring and quality of work assessment according to working guidelines;</li> <li>• Overall satisfaction with the EHR applications from the domain view.</li> </ul>	<ul style="list-style-type: none"> <li>• Use of e-mail communication with other health institutions;</li> <li>• Possibilities of migration to a paperless business;</li> <li>• Elements of e-business integrated into EHR application;</li> <li>• Forms of electronic reporting built in existing application support;</li> <li>• Interoperability and compatibility of EHR applications with current diagnostic systems.</li> </ul>	<ul style="list-style-type: none"> <li>• The impact of use of computers and EHR applications on patients' satisfaction;</li> <li>• The impact of health contents available on the Internet on behaviour of patients in FDO;</li> <li>• Forms of electronic communication between doctors and patients.</li> </ul>

Table 1. Structure of the framework with general description of its categories

Based on previously described framework we made a rather comprehensive questionnaire. In total there are 118 questions of which 103 issues have been defined for assessment. These 103 questions for the assessment consist of 32 multiple choice questions in a Likert scale of 1-5, 54 questions with dichotomous answers (YES-NO i.e. 1 or 0), and 17 questions with offered answers that should be marked. General questions about the doctor and his/her office are very important for assessing the quality of the population sample. In addition, based on information about the structure of the measured population we can perform comparison of the results depending on the specific groups within the population (e.g. gender, specialization, age, years of service, etc.). The time allocated for completing the questionnaire was estimated at 20 minutes. The questionnaire therefore is rather straightforward and easy to use and populate.

Given that the questionnaires as this are very cumbersome to display on the site of small format, Table 2 shows the part of the questionnaire form with general questions about the doctor and his/her office, while Table 3 shows the main part of the questionnaire form for all six categories for assessment broken on multiple pages. Each category i.e. part of the questionnaire with each other is separated by a space line. For easier orientation in the questionnaire, all items i.e. questions are numbered. Questions are marked with a combination of the ordinal number of subcategories within the main category and the ordinal number of questions within the subcategories.

Data about FDO	County:	
	Municipal:	
	City:	
	FD office type:	a) urban b) rural c) insular
	FD office autonomy:	a) in a health center b) under lease c) private
	Practice organization:	a) standalone b) group practice
Data about FD	Age:	
	Years of working:	
	Gender:	M - F
	Specialization?	Yes - No
	Do you use in your work the computer and the application for managing of EHR?	Yes - No
	Name of the EHR application (program) that you use:	

Table 2. Part of the questionnaire form with general questions about the doctor and his office

A	Question	Answer		
1.1	How long have you been using the computer in your practice? (years, months)			
1.2	Do you use a computer to record administrative data about patients?	Yes - No		
2.1	Who performs an update of administrative patient data?	a) doctor b) nurse	c) doctor and nurse d) administrator	
2.2	Do you use your computer for recording of patients' medical data?	Yes - No		
2.3	Who performs an update of medical information about patients?	a) doctor b) nurse	c) doctor and nurse d) administrator	
2.4	Do you use your computer during the examination and interview with the patient?	Yes - No		
3.1	Evaluate the impact of using of the computer on the quality of your work in the office.	significantly reduces the efficiency	1 - 2 - 3 - 4 - 5	significantly increases the efficiency
3.2	Evaluate the impact of computers due to the dynamics of your practice.	significantly slows	1 - 2 - 3 - 4 - 5	significantly accelerates
4.1	Express your opinion on the impact of the degree of integration of health information systems on the efficiency of the entire health system.	significantly reduces the efficiency	1 - 2 - 3 - 4 - 5	significantly increases the efficiency
4.2	Express your opinion on electronic prescribing of drugs (e-Prescription).	I do not support at all	1 - 2 - 3 - 4 - 5	I fully support
4.3	Express your opinion on electronic referral of patients (e-Referral).	I do not support at all	1 - 2 - 3 - 4 - 5	I fully support
4.4	Express your attitude about the secondary use of medical records of patients for the purpose of development and progress of the entire health care system.	I do not support at all	1 - 2 - 3 - 4 - 5	I fully support
4.5	Express your attitude about the creation of a central registry of electronic health records for all patients ("central EHR").	I do not support at all	1 - 2 - 3 - 4 - 5	I fully support

B	Question	Answer		
1.1	Does the nurse use a separate computer that is networked with your computer?	Yes - No		
1.2	Who performed the installation of your computer and network support in the office?	a) equipment supplier b) software vendor	c) friends or acquaintances d) yourself	
1.3	Which operating system are you using on your computer?	a)MS Windows XP b)MS Windows Vista c)MS Windows 7	d)MacOS c)Linux	
1.4	On which way are you connecting to the Internet?	a) modem (PSTN) b)ISDN c)ADSL	d)GSM or similar e)through the proxy of the greater network	
1.5	Does your nurse have access to the Internet?	Yes - No		
1.6	Rate the size of the cost of the hardware and network support in your practice.	very small	1 - 2 - 3 - 4 - 5	very large
1.7	Rate the size of your office communication costs.	very small	1 - 2 - 3 - 4 - 5	very large
2.1	How many of the EHR applications you changed so far? (number)			
2.2	Is your current HER application certified to work on the central HIS (CEZIH)?	Yes - No		
2.3	Rate the quality and availability of contextual help system in your EHR application (e.g. press the F1 key for the current problem)?	very poor or there is no	1 - 2 - 3 - 4 - 5	high quality and accessible
2.4	Rate telephone support system (helpdesk), if it is ensured by the vendor of your EHR application?	very poor or there is no	1 - 2 - 3 - 4 - 5	high quality and accessible
2.5	Rate the remote administration and troubleshooting, if it is ensured by the vendor of your EHR application?	very poor or there is no	1 - 2 - 3 - 4 - 5	high quality and accessible
2.6	Rate the remote version update, if it is ensured by the vendor of your EHR application?	very poor or there is no	1 - 2 - 3 - 4 - 5	high quality and accessible
2.7	Rate the remote update of prescribed nomenclatures, if it is ensured by the vendor of your EHR application?	very poor or there is no	1 - 2 - 3 - 4 - 5	high quality and accessible
2.8	Rate the size of the cost of the software support in your practice.	very small	1 - 2 - 3 - 4 - 5	very large
3.1	Do you use any kind of equipment that provides computer-readable results (ECG, spirometry, ultrasound, holter, etc.)?	Yes - No		

3.2	Mark a letter before the name of the equipment that you use, and which can be connected to your computer. (multiple answers possible)	a) ECG b) spirometer c) blood pressure gauge	d) ultrasound e) ECG holter f) RR holter
4.1	Which of the following actions require, in your opinion, a greater degree of security and data protection?	a) transactions between bank accounts b) transmission of electronic health records c) both equally	
4.2	Which of the following categories, in your opinion, is more important for patient safety in health care system?	a) protection against of unauthorized access to patient data b) timely access to patient's data c) both equally	
4.3	Which are the safety and privacy protection elements that you use in your practice? (multiple answers possible)	a) physical access limitation (locking) b) password on the PC startup c) password on the entrance of the EHR application d) encrypting the entire contents of the hard disk e) none of the above	
4.4	Which are the elements of protection against data loss that you use in your office? (multiple answers possible)	a) regular data backup included in EHR application b) making of additional backup copies which are stored separately c) use of the devices for uninterruptible power supply (UPS)	
5.1	Do you know what the IHE certification is? (short explanation - full name)	Yes - No	
5.2	Do you know what the HL7 standard is? (short explanation - purpose)	Yes - No	
5.3	Do you know what the EN13606 standard is? (short explanation - purpose)	Yes - No	
5.4	Do you know what the DICOM standard is? (short explanation - purpose)	Yes - No	
5.5	Should the doctors be, at least roughly, familiar with the above standards and recommendations?	Yes - No	

C	Question	Answer		
1.1	Did you attend any kind of informatics schools or courses in the past five years?	Yes - No		
1.2	Rate your level of IT knowledge.	very low	1 - 2 - 3 - 4 - 5	very high
1.3	Rate the doctors' overload with necessary level of ICT knowledge.	very low	1 - 2 - 3 - 4 - 5	very high
1.4	Rate your level of domain (medical) knowledge.	very low	1 - 2 - 3 - 4 - 5	very high

2.1	Rate the frequency of your visits to bibliographic databases on the Internet.	rarely (or never)	1 - 2 - 3 - 4 - 5	often
2.2	Rate the frequency of your visits to health portals on the Internet.	rarely (or never)	1 - 2 - 3 - 4 - 5	often
2.3	Rate the frequency of your visits to e-journals on the Internet.	rarely (or never)	1 - 2 - 3 - 4 - 5	often
2.4	Rate the intensity of use of e-mail in the life and work.	rarely (or never)	1 - 2 - 3 - 4 - 5	often
2.5	Do you know what HON certificate is? (brief description - purpose)	Yes - No		
3.1	Have you been engaged in developing and testing some of the CEZIH certified EHR applications?	Yes - No		
3.2	Are you a member of an informal group of doctors who help each other in their work with purpose of better understanding and use of EHR applications?	Yes - No		
3.3	Do you have the role of "leader" in such a group?	Yes - No		
4.1	Do you use the information from your computer application for the professional evaluation of your work?	Yes - No		
4.2	Do you use the information from your computer application for administrative and financial evaluation of your work?	Yes - No		
4.3	Do you use the information from your computer application for your research work?	Yes - No		
5.1	How often do you change the password for entry into the EHR application?	a) daily b) weekly c) monthly	d) sometimes (not too often) e) still use the first one f) I do not use a password	
5.2	How the doctors, who replace you in your absence, realize access to your EHR application?	a) use my account b) I open new user account for every replacement c) I have opened a special account for replacement regardless of the physician		
5.3	How often do you make EHR data backup?	a) daily b) weekly c) monthly	d) sometimes e) after each change f) I do not perform backup	

D	Question	Answer		
1.1	Rate how your EHR application follows the domain workflow i.e. organization of the work (SOAP).	very bad	1 - 2 - 3 - 4 - 5	very well
1.2	Evaluate the usability of the user interface of your application (ease of handling and intuitiveness).	very difficult and confusing	1 - 2 - 3 - 4 - 5	very easy and intuitive
1.3	Is in your EHR application visible reason and the content of previous patient's visit(s), prior to entering data of a new visit?	Yes - No		
2.1	Mark the letter before the name of the disease classification which your application supports. (multiple answers possible)	a) ICD10 b) ICPC-2	c) Read d) SNOMED	
2.2	Is your EHR application capable for structured and atomized input of patient's vital parameters?	Yes - No		
2.3	Is your EHR application capable for menu oriented input of previously defined items (instead of typing a free text)?	Yes - No		
2.4	Does your EHR application contains regularly updated list of drugs prescribed by the Ministry of Health and Social Welfare?	Yes - No		
2.5	Does your EHR application contains regularly updated nomenclatures of diagnostic procedures prescribed by the Ministry of Health and Social Welfare?	Yes - No		
2.6	Does your EHR application contains regularly updated sets of working guidelines prescribed by the Ministry of Health and Social Welfare?	a) Yes, on the computer b) No, but, if necessary, it connects me with MHSW Internet portal	c) No, nor it connects me on external sources d) I don't know	
2.7	Does your EHR application contain regularly updated nomenclature of medical institutions as prescribed by the Ministry of Health and Social Welfare?	Yes - No		

!!!	NOTE: The set of questions 3.x refers to a systems which based on the described state of the patient helps the doctor by offering a closest solution (or several solutions) as assistance for a final decision. These systems can be part of the application and / or built in diagnostic equipment (e.g. ECG with auto-diagnostic). In the case of drug prescribing, these systems are based on possible drug interactions and side effects, etc.			
3.1	Does your EHR application have inbuilt functionalities for diagnosis decision support?	Yes - No		
3.2	If your previous answer is "Yes", rate the quality and usability of the system.	completely useless	1 - 2 - 3 - 4 - 5	fully usable
3.3	Are you using an advanced decision support system for determining a diagnosis independent of your EHR application (software or equipment with inbuilt functionalities)?	Yes - No		
3.4	Does your EHR application has inbuilt advanced helping functionalities for drug prescribing?	Yes - No		
3.5	If your answer is "Yes", rate the quality and usability of the system.	completely useless	1 - 2 - 3 - 4 - 5	fully usable
3.6	Does your EHR application has inbuilt advanced helping functionalities to assist physicians to refer patients for further treatment?	Yes - No		
3.7	If your previous answer is "Yes", rate the quality and usability of the system.	completely useless	1 - 2 - 3 - 4 - 5	fully usable
3.8	Rate how your EHR application monitors chronic diseases?	very poor or not at all	1 - 2 - 3 - 4 - 5	very good
3.9	Rate how your EHR application monitors allergies?	very poor or not at all	1 - 2 - 3 - 4 - 5	very good
4.1	Does your EHR application has some visible indicators (gauges, visual indicators) that alerts you to the current efficiency and the quality of your work (rates and coefficients)?	Yes - No		
4.2	Does your EHR application has any form of an advanced system for short-term and long-term evaluation of the quality of your work?	Yes - No		
5.1	From domain point of view, rate the overall satisfaction with your EHR application.	very unsatisfied	1 - 2 - 3 - 4 - 5	very satisfied
5.2	From domain point of view, compare your CEZIH compatible application with the application you were using before CEZIH system.	significantly worse	1 - 2 - 3 - 4 - 5	much better

E	Question	Answer
1.1	Do you use e-mail to communicate with your colleagues in primary health care?	Yes - No
1.2	Do you use e-mail for communication with specialists in clinics?	Yes - No
1.3	Do you use e-mail for receiving of laboratory results of your patients?	Yes - No
1.4	Do you use e-mail for receiving of specialist medical examination of your patients?	Yes - No
1.5	Do you use web-services or e-mail for ordering patients to specialists in clinics (e-ordering)?	Yes - No
2.1	Do you store medical documents received by e-mail in the particular folders inside of your EHR application?	Yes - No
2.2	Do you scan medical paper documentation of your patients and store them in electronic form to particular folders of your EHR application?	Yes - No
3.1	Can you perform e-ordering directly from your EHR application?	Yes - No
3.2	Does your EHR application support an electronic referral (e-referral)?	Yes - No
3.3	Does your EHR application support electronic drug prescribing (e-prescription)?	Yes - No
4.1	What is the form of the reports that you submit to the Croatian Institute for Health Insurance?	a) paper form b) paper form and floppy disk c) electronically through the web portal CEZIH d) electronically directly from the application
4.2	Does your application support electronically reporting to the Croatian Institute for Health Insurance?	Yes - No
4.3	Does your application support electronically reporting to Public Health?	Yes - No
4.4	Is your application ready for exchange (synchronization) of medical data with a central registry of EHRs?	Yes - No

4.5	Can you from your EHR application directly check the status of the insured patient in the Croatian Institute for Health Insurance?	Yes - No
5.1	What do you do when foreign and, increasingly, domestic insured, bring you the results of diagnostic procedures (X-ray, CT, MRI, etc.) made on CD or DVD?	a) I browse the pictures on the computer, and store the medium with patient's paper documents b) I browse the pictures on the computer, and store them in the particular folders of my EHR application c) I do not browse the pictures, but I ask the patient to bring me a hardcopy of findings (film or paper)
5.2	Does your application allow direct preview and storage of these digital records?	Yes - No

F	Question	Answer		
1.1	Rate the satisfaction of the patients with using of the EHR application in your practice.	very unsatisfied	1 - 2 - 3 - 4 - 5	very satisfied
1.2	Do you grant to your patients, on their request, insight into their medical history on your computer?	Yes - No		
1.3	Do you issue to your patients a complete history of his/her illness in electronic form (CD, floppy, etc.), for the purpose of the transfer to another physician and to ease work to the newly elected physician and, also, to contribute to patient's safety?	Yes - No		
2.1	Do your patients use available health contents on the Internet to be further informed about their condition?	Yes - No		
2.2	Do your patients comment with you the information about their problems that they have been collected on the Internet?	Yes - No		
3.1	Do you use e-mail to communicate with your patients?	Yes - No		
3.2	Do you use some form of electronic ordering patients for examination in your practice?	Yes - No		
3.3	Do your patients use e-mail for delivering of information about their medical condition (e.g. monitoring of chronic disease)?	Yes - No		
3.4	If your office has its own web page, which contents are available on it? (multiple answers possible)	a) advertising b) health advices c) e-ordering system d) useful links to other health contents	e) subsystem for acquisition of data for monitoring of chronic diseases f) I have no web page	

Table 3. The main part of the questionnaire form with questions for assessment purpose

## 5. Analysis of survey process and data collected

The survey was conducted during the period from mid-December 2009 until the end of January 2010. Questionnaire was made in electronic PDF/FDF form with the ability to automatically return to the sender via e-mail, and in the classical paper form. The questionnaires in electronic form were offered via dedicated mailing list, which has approximately 1100 formal users (assuming that the number of active users is much smaller), while about 70 questionnaires were distributed in paper form at the professional meetings and collected on spot or received by post. Random sample selection depended on FDs' free will to fill the questionnaire.

A total of 115 complete and correctly filled questionnaire forms were collected (87 or 75.7% of 115 in electronic and 28 or 24.3% of 115 in paper form). Therefore, we included approximately 4.7% of total 2450 Croatian FDs. By analysis of general data about the respondents and their offices, we got the structure of the analysed sample, which is showed in Table 4.

Category	Characteristics		
Age	Median: 49	Interquartile range: 44 - 51	
Years of working	Median: 23	Interquartile range: 18 - 26	
Gender	Male: 23,6 %	Female: 76,4 %	
Specialization	Yes: 66 %	No: 34 %	
FD office autonomy	Health center: 18,9 %	Under lease: 69,8 %	Private: 11,3 %
FD office type	Urban: 64,1 %	Rural: 32,1 %	Insular: 3,8 %

Table 4. Characteristics of tested sample of the Croatian family doctors and their offices

By comparison of data from well-known official Croatian health statistical publications (Baklačić et al., 2007), and data known from some previous analysed works (Kern & Polašek, 2007; Kralj & Tonković, 2009) with data showed in Table 4, it can be concluded that analysed sample is representative enough to draw conclusions from the study.

For the purposes of the upcoming numerical and statistical analysis, a quantification of the collected responses was performed. In addition to quantitative analysis, we performed a qualitative analysis of collected data that can assess the actual state of e-Health concept implementation, and point on the existing problems and shortcomings of the current model of e-Health concept implementation.

## 6. Results analysis and discussion

The results of qualitative and quantitative analysis of the categories and total experience are shown in Table 5. Due to limited space, the qualitative ratings are summarized for the most important elements, while the quantitative rates provide fairly realistic overall scores on a scale from 0 to 1. Prior to conducting of the survey, we hypothesized that actual state of the implementation of e-Health concept in the Croatian primary health care corresponds to the descriptive assessment: "somewhere halfway". The presented overall quantitative result to some extent confirms this assessment.

Category	Results
A	<ul style="list-style-type: none"> <li>-40% of FDs believe that the new system and EHR applications slow down their work;</li> <li>-In 4.3% of FDOs nurses write medical information in the EHR, while in 10.4% of FDOs the doctor updates the administrative and demographic data of patients;</li> <li>-34% of FDs do not support e-prescribing, while 35% do not support e-referral;</li> <li>-50% of FDs are mainly against the secondary use of medical data;</li> <li>-66% of FDs do not believe in the security and confidentiality of data in a central EHR;</li> </ul> <p style="text-align: center;">Mean rate: 0.696      Items: 12      Cronbach <math>\alpha</math>: 0.667</p>
B	<ul style="list-style-type: none"> <li>-All contracting FDOs are equipped with the necessary ICT equipment;</li> <li>-Automatic remote software update is provided for all EHR applications;</li> <li>-All EHR applications use the same formal structured and coded lists of health registers and nomenclatures that are automatically updated on a regular basis;</li> <li>-All EHR applications have authorized access and role specific access rights;</li> <li>-41% of FDs have some diagnostic devices that provides results in an electronic format suitable for inserting in EHR;</li> <li>-Transfer to another EHR application is rather difficult due to portability and “data lock” issues (including basic demographic data, prescriptions, referrals, and several types of reports)=&gt; EHR is not longitudinal in its most important part;</li> </ul> <p style="text-align: center;">Mean rate: 0.555      Items: 24      Cronbach <math>\alpha</math>: 0.694</p>
C	<ul style="list-style-type: none"> <li>-13% of FDs believed to be overloaded with unnecessary knowledge of IT technologies;</li> <li>-50% of FDs considered that they should have at least roughly knowledge of the norms and recommendations upon which is based the e-Health concept;</li> <li>-26% FDs attended IT schools or courses in the past 5 years;</li> <li>-17% of FDs assess their IT knowledge as very high;</li> <li>-24% of FDs are members of some informal groups for helping in better understanding of functionalities of their EHR applications;</li> <li>-57% of FDs use the data from their EHR applications for quality evaluation of their work;</li> <li>-75% FDs give to their replacement doctors to work on their user account (security risk);</li> <li>-Only 60% of FDs make daily backup their data (EHR);</li> </ul> <p style="text-align: center;">Mean rate: 0.427      Items: 18      Cronbach <math>\alpha</math>: 0.722</p>
D	<ul style="list-style-type: none"> <li>-In only 34% cases FDs considered that EHR applications very well follow domain work flow, while in 49.6% of the cases considered that the user interface is user friendly and intuitive;</li> <li>-All applications support atomized entry of demographic and administrative data for uniquely identified patient, which are available from all parts of his EHR;</li> <li>-In 61% of EHR applications is possible atomized (structured) input of the physical status;</li> <li>-All applications contain ICD-10 classification of diseases, and equal central updated nomenclatures of procedures, medication and health care institutions;</li> <li>-In 72.6% and 75.4% cases EHR applications offer support for chronic disease and allergies monitoring, respectively</li> <li>-Decision support systems are in their beginnings as a simpler forms of work assistance;</li> <li>-In 41.5% cases EHR applications have built-in clinical and pharmacological guidelines;</li> <li>-In 51.9% cases EHR applications have built-in visual indicators for the financial indexes for diagnostic-therapeutic procedures, drug prescribing and the rate of sick leave;</li> <li>-35.7% of FDs are very satisfied with the overall domain properties of their EHR application;</li> </ul> <p style="text-align: center;">Mean rate: 0.430      Items: 23      Cronbach <math>\alpha</math>: 0.822</p>

Category	Results
E	-All EHR applications are capable for e-prescribing and e-referral (not in function in testing time); -All EHR applications have the ability to add scanned paper-based diagnostic test results into the EHR, but only 22.6% of FDs use this feature; -EHR applications support some forms of electronic reporting (not all yet fully implemented in the central system); -82.6% FDs communicate by email with their colleagues in primary health care, while only 18.3% with doctors in clinics and hospitals; -All EHR applications are capable to remotely check the patient's health insurance status;
	Mean rate: 0.324      Items: 17      Cronbach $\alpha$ : 0.689
F	-In 23.5% cases patients are satisfied with the implementation of the new information system; -EHR applications currently do not provide patients with reports on their health status in electronic human readable format; -Only 27% of FDs communicate with patients via e-mail and other electronic media; -Only 9.6% FDs collect information about chronic diseases of their patients via e-mail.
	Mean rate: 0.446      Items: 9      Cronbach $\alpha$ : 0.541
Overall	Mean rate: 0.48      Items: 103      Cronbach $\alpha$ : 0.886

Table 5. Major qualitative results, average quantitative results and reliability coefficients of experiences assessment presented by categories

To determine and prove the reliability of our measurement tool, we used a calculation of the Cronbach  $\alpha$  coefficient of correlation for each of categories (Cronbach, 1951). The recommended amount of this coefficient for a high degree of reliability, i.e. internal consistency of questionnaire, is  $\geq 0.7$ . Before calculating the Cronbach  $\alpha$  coefficient, we conducted verification of the required sample size with Bonett's formula (Bonett, 2002) using null hypothesis of Cronbach  $\alpha$  coefficient equal to 0.7, against a two-sided alternative at  $\alpha=0.05$  and power  $(1-\beta)=0.8$ . For total number of 103 items and estimated coefficient to approximately 0.8, we calculated a minimum sample size of 41, which is significantly less than our 115. Cronbach  $\alpha$  calculation was performed with SPSS Statistics 17.0.

Our population sample was not previously prepared for the testing. For this type of testing are common slightly smaller amounts of the Cronbach  $\alpha$  than in controlled or clinical conditions. As we see from Table 5, the lowest Cronbach  $\alpha$  has a category of social experience (0.541), however, it is a common occurrence in the questionnaires that have fewer than ten questions. So called face validity and content validity (Khoja, 2007b) of our measurement tool were confirmed through interviews and commentaries of the doctors. Comments were positive, and confirm the relevance of all categories in over 75% of cases. To determine the detailed structural validity we should apply factor analysis. To determine accuracy, it would be necessary to carry out additional field researches and calculations of correlations. The reliability and validity do not automatically withdraw the accuracy of the collected data. Although it is theoretically possible to achieve higher reliability and internal consistency of the questionnaire with incorrect data, sufficient reliability is a prerequisite for accuracy. We see this as the subject of further research.

As we see from the results presented in Table 5, categories A, C and partly F reflect the doctors' views about essential objectives of the e-Health concepts and doctors' engagement

in achieving these goals. From the results of all other categories we can see how EHR applications meet the current worldwide certification criteria. Based on identified system performance, and current Croatian certification criteria (CIHI, 2010), we can conclude that Croatian EHR applications would be able to almost entirely meet the criteria of EuroRec EHR-Q Seal 1 and in some parts even the Seal 2 criteria, which is subject to more detailed analysis. However, in domain functionality, which is better covered by American ONC Meaningful Use of HER Stage 1, is still necessary to significantly improve the functionality. Here we primarily mean the introduction of full electronic data (clinical and administrative) interchange with all health care organizations, insurers and, of course, patients. Furthermore, we see some encouraging first results in applying of the working guidelines, guideline-based decision support systems and monitoring of chronic diseases and allergies. A similar situation is with monitoring and indication of the quality of doctor's work. These are definitely significant areas of further improvement.

## **7. Possible directions for future research**

Continued research in order to improve our measurement methodology i.e. our measurement tool, is more than essential. It is necessary to continuously align our measurement methodology with best international practices. We expect that assessment of doctors' attitudes and their engagement in acquiring of the ICT knowledge will be of minor importance in the coming period, because, as the information system evolves, awareness and ICT knowledge of medical population becomes larger, and the focus of interest becomes the functionalities of applied software solutions. Judging by the latest global trends, the greater importance will have functionalities that contribute to the e-Health privacy and security, use of decision support systems in order to increase the quality of treatment, and, of course, functionalities that will allow patients to monitor phases of their own treatment and to more easily achieve their rights. References for that have to be drawn from the European projects and thematic networks such as epSOS (Smart Open Services for European Patients) (epSOS, 2011) and CALLIOPE (Call for Interoperability) (CALLIOPE, 2011). Objective of these projects is the harmonization of functionalities of the EHR applications and legislations among the current and future EU Member States in order to achieve cross-border interoperability. As we pointed out previously in the discussion, another important area of further research is the application of appropriate statistical methods to determine the reliability and accuracy of the measurement. In addition, development of appropriate statistical methods is essential for comparison of the measurement results between different stages of development of the applied EHR systems.

## **8. Conclusion**

In this article, we have presented some preliminary results of what is envisioned to be a comprehensive methodology and criteria to measure quality of EHR system implementations in primary health care. Lord Kelvin once said: "If you can not measure it, you can not improve it." So, the focus of this article was on a measuring tool which is the basis for data analysis that serves to identify some key areas of quality to measure. From the amount of collected survey data and results of their analysis, we can conclude that in the practical implementation of this assessment method exist certain problems. The form of the questionnaire is very complex since it is necessary to perform testing of measured

population across all categories simultaneously and in one pass. This can result in a weaker survey response of the tested population. However, with a simple questionnaire we could not manage to collect enough of useful information. Furthermore, one can say that our methodology is limited because the assessment of the functionalities of EHR applications is reduced only to the functionalities that are visible to doctors and can be expressed as an experience. However, we must be aware that in the quality EHR application, all the key features must be visible, or at least well-documented in the user guide and contextual help system. Analysis of data collected by our measurement tool can be held within six basic categories, but it is possible to evaluate the categories i.e. functionalities that are derived from a combination of basic categories. For example, by combining data from several basic categories, we can analyse functionalities such as the implementation of working guidelines and decision support systems (Kralj et al., 2010), or patients' privacy and safety protection (Kralj et al., 2011). We entered in the designing process of our measurement tool with the main idea to construct and implement an open type methodology. That means that we have decided to continuously align our measurement methodology with best international practices. Croatian certification criteria are still mainly based on the local requirements and needs of current developments, and do not draw direct reference to some of the internationally recognized quality indicators and frameworks, or take into account clinical protocols, experts practice and expectations on readiness and experience by users. Since the certification of EHR applications is performed by successive stages of development, we expect to be relatively easy to fully comply with worldwide technical criteria, however it remains to be seen what additional requirements we will identify as important, or how would international certification processes apply to localized environments and large scale deployment. The preliminary results give us confidence that our assessment methodology could be used as the potential tool for monitoring of further improvements of Croatian certification criteria, also in respect to forthcoming development phases of the Croatian healthcare information system.

## 9. Acknowledgment

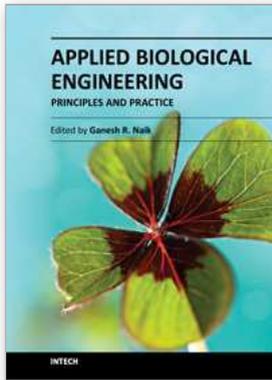
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## **Applied Biological Engineering - Principles and Practice**

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Biological engineering is a field of engineering in which the emphasis is on life and life-sustaining systems. Biological engineering is an emerging discipline that encompasses engineering theory and practice connected to and derived from the science of biology. The most important trend in biological engineering is the dynamic range of scales at which biotechnology is now able to integrate with biological processes. An explosion in micro/nanoscale technology is allowing the manufacture of nanoparticles for drug delivery into cells, miniaturized implantable microsensors for medical diagnostics, and micro-engineered robots for on-board tissue repairs. This book aims to provide an updated overview of the recent developments in biological engineering from diverse aspects and various applications in clinical and experimental research.

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Phone: +86-21-62489820  
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