The role of Data Science in EHR: How Medical Decision Making can be improved based on Comprehensive EMR?

Ali Azadi

Supervisor: Francisco José García-Peñalvo

PLAN DE INVESTIGACIÓN

PROGRAMA DE DOCTORADO EN INGENIERÍA INFORMÁTICA

Marzo 2022

INTRODUCTION

 Nowadays, because of the Corona virus consequences and some events during the people's life majority of them know the importance of medical treatments and it will lead to grow up some concepts and knowledge to help the patients all over the world. Computerization of the patient's treatment process can help the Doctors and physicians especially when the data arrangement be observed carefully. An application environment composed of the clinical data repository, clinical decision support, controlled medical vocabulary, order entry, computerized provider order entry, pharmacy, and clinical documentation applications. This environment supports the patient s electronic medical record across inpatient and outpatient environments, and is used by healthcare practitioners to document, monitor, and manage health care delivery within a care delivery organization (CDO). The EMR is the legal record created in hospitals and ambulatory environments that is the source of data for the EHR. The EHR (Electronic Health Record) represents the ability to easily share medical information among stakeholders and to have a patient s information follow him or her through the various modalities of care engaged by that individual. Stakeholders are composed of patients/consumers, healthcare providers, employers, and/or payers/insurers, including the government. EHRs are reliant on EMRs being in place, and EMRs will never reach their full potential without interoperable EHRs in place. But before we can move to effective EHR environments, provider organizations must implement complete EMR solutions. At this point, few hospitals have EMR solutions that can effectively reduce medical errors or improve the quality and efficiency of patient care [1].
 In this regard, Data Science can be placed next to EMR and helps to improve it. Healthcare and data science were made for each other. Accessible, informative patient data is critical to good care. When healthcare and data science are combined, the result is electronic health records. EHR use data science for the benefit of medical treatments and procedures. Additionally, healthcare provides the perfect input for artificial intelligence (AI) and machine learning (ML)algorithms [2]. Information dashboards are sophisticated tools. Although they enable users to reach useful insights and support their decision -making challenges, a good design process is essential to obtain powerful tools [3, 4].

 The most valuable is the care delivery, which is based on rigorous scientific knowledge and has the minimum cost with maximum benefit for patients. Costs are determined not so much by the money spending of treatment, as by the time and effort the patient spends on the treatment, and also by the number of staff-hours. That is why it is necessary to carry out comprehensive efforts that will reduce costs and improve the quality of treatment to provide a quality healthcare delivery [5]. Clinical Decision Support systems (CDSS) take their information from forms were filled in EHR and can provide incomplete advice due to incomplete and unstructured EHR [6].

 There is a potential disconnect between points at which professional and lay eHealth data and resources intersect for preventative or proactive health care. Such gaps in information sharing may have directimpact on practices we decide to take up, the care we seek, or the support professionals offer. HCI has a role towards enhancing health knowledge discovery and health support interaction [7, 8].

A combination of science, technology, and medicine in the dynamic digital age has unveiled new data systems to improve statistics, improve healthcare and drug delivery, and improve health information reporting on clinical decisions.
Data science in health care has seen the latest and most rapid progress in 3 ways:

1- Using big data with a combination of large and complex data sets includes electronic medical records, social media, genomic information, and digital body data from wireless health devices.
2- With new open-access efforts that seek to utilize the availability of clinical trials, research, and citizen science sources for data sharing.
3- In the analysis techniques, especially of big data, including machine learning and artificial intelligence that can improve systematic and unstructured data analysis [9].

If medical data including medical history, drug consumption, lab results, comprehensive information related to disease symptoms and even some especial personal habits like smoking have been registered in EMR and they have been arranged based on data science and purposefully, it will lead to increase the accuracy of medical decision making significantly. In this investigation we discuss about the data integrity [10] and comprehensiveness of EMR for better CDSS.

WORKING HYPOTHESIS AND PRINCIPAL OBJECTIVES SOUGHT

Aims:

In this investigation we try to indicate that to what extend the complete and good data structure in EHR, beside the combination of AI and HCI will help to CDSS and even the fate and cost of the patients. So the purposes of this research are as following:

1- Identify the factors which should be considered for designing and implementing medical data forms in EMR based on Data Science.

2- Increasing the comprehensiveness of EMR, effects on accuracy of Medical Decision Making.

3- Propose HCI models that improve the CDSS user experience.

Hypothesis:

The combination of AI and HCI processes will improve the Medical Decision Making in CDSS.

Questions:

Main Question: How AI and HCI together and hand-in-hand will improve CDSS? What is the role of Comprehensive EMR in this way?

- Which attributes should be defined (based on Data Science) to identifying the comprehensive EMR?

- What will be the effects of optimization of EMR about accuracy level of CDSS?

- How do we define the HCI models which improve CDSS user experience?

METHODOLOGY

1- SLR:

One of the first tasks before conducting a research, regardless of the field of study, is to identify related works and previous studies as a way to support the need to conduct new research on a particular topic. Likewise, the review of available research provides answers to particular research questions and a knowledge base to learn from previous experiences and identify new research opportunities. Nevertheless, although the need to synthesise research evidence has been recognised for well over two centuries, it was not until the end of the last century that researchers began to develop explicit methods for this form of research [11.]
Literature review is an essential feature of academic research. Fundamentally, knowledge advancement must be built on prior existing work. To push the knowledge frontier, we must know where the frontier is [12]. At first in this investigation, we will try to achieve principal factors which are crucial to observe in EMR. In this regard, we will perform a systematic review [13-15] to define the criteria which EMR system is considered as Comprehensive EMR. In this part of study will be investigated whole the previous studies (systematic review) about relation between EMR and CDSS and how they do they interact with each other.

2- Design Science Research(DSR) Methodology:

When we know whole criteria for Comprehensive EMR, we start to review medical forms in EHR and if appropriate redesign them and their relationship and then evaluate them several times and repeatedly using DSR methodology [16-17]. In this research we will employ System Usability Scale to evaluate the EMR systems [18].

3- Qualitative Methods:

As all the physicians, nurses, doctors and medical groups are using the EMR system and they need to communicate with this system closely and friendly, so it is necessary to pay attention to HCI (Human Computer Interaction) dimension of designing EMR. satisfaction with the system will allow physicians to enter more correctly and quickly all required information, and on the other hand, it will improve the quality of the data itself for their subsequent analysis [5]. Overall user satisfaction was most highly correlated with screen design and layout, and surprisingly not with system response time. Human-computer interaction studies can help focus our design efforts as we strive to increase clinician usage of technology [19].

So, in this investigation we will propose HCI model to improve CDSS. In this model we have considered all user's need and their attitude to utilize EMR efficiently.

MATERIAL MEANS AND RESOURCES AVAILABLE

This work is developed in the Doctorate Program Training in Informatics faculty of Salamanca University and under supervising of Professor García Peñalvo as head of GRIAL Group.

In addition, this thesis will be developed in GRIAL Group and as a research project [20] has employed various resources such as Internet, statistical software, digital libraries, web of science, Scopus and also access to some necessary data bases (belong to the medical centers and hospitals) in order to data extract as the case study.

In all cases, the necessary provisions will be made to observe the confidentiality of patients' information. It means that identification fields in the mentioned data bank will be changed to the unknown fields.

The result of this thesis will be open accessible for the future researches.

TIMING SCHEDULE OVER THREE YEARS

 This investigation is intended to be carried out full-time, which is estimated to last approximately three years. The doctoral thesis aims to be presented through several articles which will be written during this period and whose sequence is detailed in the following:

During the first year, the doctoral plan will be developed and, in addition, a systematic literature review (SLR) will be carried out, to see the starting point of the doctoral thesis and access and collecting the existing researches which have been done especially in the recent years about related issues.

In the first half of the second year, after the systematic review of the literature to know the current situation and related publications, the next steps will begin to perform appropriate correspondence with some medical centers and hospitals (as the case study) whose necessary platform (EMR) will be able to use for data analysis.

The second half of the second year will be used to analyze data obtained from EMR platforms of the mentioned centers, try to draw conclusions, contrast the information and make at least one publication based on the findings in International Conferences or Journals such as followings:

- International Journal of Human–Computer Interaction
- International Journal of Digital Health
- International Conference on eHealth, Telemedicine and Social medicine
- TEEM Conference

In the third year, when we will achieve one HCI model (after several necessary evaluations) to improve CDSS, at least one publication will be made and the findings and publications will be brought together for the thesis, and it will be lead to perform completely the thesis.

The necessary actions during these three years are included in the Table 1:

Table 1. Gantt Chart of thesis processes

Task	2021-2022												2022-2023												2023-2024											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Data Extraction	review and collecting related works												updating the systematic review												Updating the systematic review											
Inclusion and exclusion criteria	Quality Assessment of the studies												Quality Assessment of the studies												Quality Assessment of the studies											
Performing publication related to Phd thesis																				writing an academic paper													Writing an academic paper			
Necessary experimental actions															perform experiments on main case study																					
															Re-design data forms		Deploy EMR		Data analyzing																	
															Evaluate using system usability scale																				
Proposing the HCI model in order to improve CDSS																									Design HCI model	Implenetation model		Evaluation		Propose the HCI model							
Preparing the Dissertation																													Write the Dissertation			Revision		Finalize		
Dissertation Defense																																				Defense

REFERENCE

[1] D. Garets and M. Davis, "Electronic Medical Records vs. Electronic Health Records: Yes There is a difference," HIMSS Analytics, 2006.

[2] H. West, "Healthcare and Data Science: How EHR and AI can go Hand-in-Hand," Technology Networks, 2020.

[3] A. Vázquez-Ingelmo, F. J. García-Peñalvo and R. Therón, "Automatic generation of software interfaces for supporting decision-making processes. An application of domain engineering and machine learning," in TEEM'19 Proceedings of the Seventh International Conference on Technological Ecosystems for Enhancing Multiculturality (Leon, Spain, October 16th-18th, 2019), M. Á. Conde-González, F. J. Rodríguez-Sedano, C. Fernández-Llamas and F. J. García-Peñalvo, Eds. ICPS: ACM International Conference Proceedings Series, pp. 1007-1011, New York, NY, USA: ACM, 2019. doi: 10.1145/3362789.3362923.

[4] F. J. García-Peñalvo et al., "Application of Artificial Intelligence Algorithms Within the Medical Context for Non-Specialized Users: the CARTIER-IA Platform," International Journal of Interactive Multimedia and Artificial Intelligence, vol. 6, no. 6, pp. 46-53, 2021. doi: 10.9781/ijimai.2021.05.005.

[5] K. V. Bolgova, S. V. Kovalchuk, M. A. Balakhontceva, N. E. Zvartau and O. G. Metsker, "Human Computer Interaction During Clinical Decision Support with Electronic Health Records Improvement," E-Health and Medical Communications, 2020.

[6] M. W. M. Jaspers, M. Smeulers, H. Vermeulen and L. W. Peute, "Effects of clinical decision-support systems on practitioner performance and patient outcomes: a synthesis of high-quality systematic review findings," Journal of the American Medical Informatics Association, 2011.

[7] A. García-Holgado and F. J. García-Peñalvo, "Validation of the learning ecosystem metamodel using transformation rules," *Future Generation Computer Systems,* vol. 91, pp. 300-310, 2019. doi: 10.1016/j.future.2018.09.011.

[8] M. Schraefel, P. André, R. White, D. Tan, T. Berners-Lee, T. Berners-Lee, s. Consolvo, R. Jacobs, I. Kohane, C. A la Datentec, L. Mamykina, G. Marsden, B. Shneiderman, P. Szolovits and D. Weitzner, "Interacting with eHealth – Towards Grand Challenges for HCI," Association for Computing Machinery, 2009.

[9] S. Raut, "Data Science In Healthcare," 3 May 2021. [Online]. Available:https://www.analyticsvidhya.com/blog/2021/05/data-science-in-healthcare/.

[10] M. Zarour, M. Alenzi, A. Tarique Jamal, A. K. Pendey, A. Masood, A. Agrawal, R. Kumar and R. Ahmad Khan, "Ensuring data integrity of healthcare information in the era of digtal health," The instituation of Engineering and technology (IET), 2021.

[11] A. García-Holgado, S. Marcos-Pablos and F. J. García-Peñalvo, "Guidelines for performing Systematic Research Projects Reviews," International Journal of Interactive Multimedia and Artificial Intelligence, 2020.

[12] Y. Xiao and M. Watson, "Guidance on Conducting a Systematic Literature Review," Planning Education and Research, 2019.

[13] Kitchenham, "Guidelines for performing Systematic Literature Reviews in Software Engineering," EBSE Technical Report, 2007.

[14] C. Wohlin, E. Mendes, K. Romero Felizardo and M. Kalinowski, "Guidelines for the search strategy to update systematic literature reviews in software engineering," Information and Software Technology, 2020.

[15] F. J. García-Peñalvo, "Developing robust state-of-the-art reports: Systematic Literature Reviews," *Education in the Knowledge Society,* vol. 23, 2022. doi: 10.14201/eks.28600.

[16] J. v. Broke, A. Hevner and A. Maedche, "Introduction to Design Science Research," SpringerNature, 2020.

[17] R. J. Wieringa, Design Science Methodolgy for Information System and Software engineering, Springer, 2014.

[18] J. R,lewis, "Item Benchmarks for the System Usability Scale," JUS (Journal of Usability Studies), 2018.

[19] D. F.Sittig, G. J.Kuperman and J. Fiskio, "Evaluating Physician Satisfaction Regarding User Interactions with Electronic Medical Record System," Informatics Professionals Leading The Way, 1999.

[20] F. J. García-Peñalvo, M. J. Rodríguez-Conde, R. Therón, A. García-Holgado, F. Martínez-Abad and A. Benito-Santos, "Grupo GRIAL," IE Comunicaciones. Revista Iberoamericana de Informática Educativa, no. 30, pp. 33-48, 2019.