

Analysis and evaluation of criteria impacting EHR adoption with AHP model

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Abstract

Information systems have been making a noticeable entrance in the healthcare, although their adoption has been slow. This paper examines the factors influencing the electronic healthcare records (EHR) adoption by modeling behavioral intention of physicians towards EHR adoption. Three main criteria: perceived usefulness, perceived ease of use and external factors along with the subcriteria, are studied by the authors. Analytical hierarchical process (AHP) model is tested through the expert judgment questionnaire of physicians in Portland metro area. PCM software and Excel were used analyze the results of the pairwise comparisons done by the experts. The results showed high importance of the Perceived Ease of Use criteria on the behavioral intensions of physicians towards EHR adoption. Search ability and user interface – subcriteria of Perceived Ease of Use had some of the highest values. Another important subcriterion in the analysis under External Factors Criteria was Cost. None of the criteria evaluated could be considered unimportant, i.e. having really low values after the analysis. All of the respondents think that EHR should be mandatory in terms of reducing of time spent and errors, improving the outcomes and productivity and in terms of optimum patient treatment.

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Introduction

In our modern world where the impact of technology is felt everywhere, information systems are making more noticeable entrance and impact in healthcare. Everybody would agree that e-mail, internet, mobile phone, video-conferencing etc. have changed our lives and made us more connected than ever before. In our everyday lives we have become used to information systems conveniences, while in other industries the adoption process is still ongoing and taking a while. What would be the main reasons for challenges? What are the challenges? What could we do that would help us better understand the adoption barriers in healthcare? How could we help? Those are some of the questions that we try to answer in this paper.

Information management frameworks have the purpose of structuring information flow and its transformation in a certain department in order to ease the flow and delivery of information as well as its improving information utilization for patient care and safety, quality, research, administration and education (Shahpori, De Los Angeles and Laupland, 2009). Electronic health records (EHR) adoption, which is examined in this paper, should utilize the modern technology to deliver applications, tools and resources to its users (administrators, doctors and patients) over internet or intranet networks for the purposes of providing healthcare. (Armstrong, et.al, 2009). EHR is a collection of health information and data, combined with results management, order entry management and decision support (Des Roches and Painter ed., 2006).

Since we are talking about caring about people's lives, there are various security policies and privacy rules that would create challenges for quick implementation of EHR systems in hospitals and clinics. Access and manipulation of information has to be secure and aimed at providing quality healthcare. According to the Health System Change 2008 Health Tracking Physician Survey, with input from 4,700 physicians (62 percent response rate), only 23.8 percent of physicians reported having a complete electronic record system and 26.9 percent had part electronic-part paper one (Des Roches and Painter ed., 2006). Some main concerns listed were getting physicians on board, training systems, loss of productivity, financial and regulatory challenges (Tyler, 2001),(Des Roches and Painter ed., 2006). These and other concerns create certain hesitation and resistance of physicians to adoption of EHR in their practices. In another more recent survey by an independent party - Medical Group Management Association - about 52.3 percent replied that they used EHR, while 35.8 percent still stored records and charts on paper(MGMA, 2011). Of those who replied that they had EHRs, only 16.3 percent completed implementation and believed that their practice optimized the use of EHRs, while 46.3 percent completed implementation and are focusing on optimizing it, 23.8 percent are in the process of implementing EHR systems, 8.2 percent are using EHR and considering switching to a different EHR system, and 5.4 percent have other variation of completed EHR implementation (MGMA, 2011). Results of both surveys show the reality of EHR system adoption in healthcare.

Figure 1 shows the results of the survey displayed in a study by Hsiao et al., where the percentage of office-based physicians with fully functional EHR system was really low in 2009 - 6.9 percent and projected to 10.1 percent in 2010.



radiologists, anesthesiologists, and pathologists. Figure 1. Percentage of office-based physicians with electronic medical

records/electronic health records (EMRs/EHRs). (Hsiao et. al., 2010), (Witter, 2009)

Misaligned incentives are another reason seen to be an issue, since benefits of healthcare information systems might not contribute enough or at first to efficiency in offices and therefore may not be attractive for the physicians. (Witter, 2009). The major benefactors appear to be payers, as opposed to potential investors (Middleton, 2005), (Ash et al., 2005). Looking from the perspective of the user would be a logical way to understand the reasons for slow adoption.

Moreover, in this paper we are going to look at the perceived understanding of the system by a specific group of users – doctors and nurses– and examine their perceived usefulness, perceived ease of use and external factors that impact their decisions to adopt of EHR systems.

Literature Review

EHR-Background

According to the Health Information Management Systems Society (HIMSS), "the electronic health record (EHR) is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting" (HIMSS). The term electronic health record (EHR) is synonymous with Electronic Patient Record (EPR), Computerized Patient Record (CPR), Electronic Health Care Record (EHCR), Virtual EHR, Digital Medial Record (DMR), Automated Medical Record, Provider-Based Patient Medical Record and Electronic Medical Record (Wen, 2007).

The purpose of a patient record is to recall observations, to inform others, to instruct students, to gain knowledge, to monitor performance and to justify interventions (Reiser, 1991) and to ultimately further the application of health sciences in ways that improve the well-being of patients (Tang & McDonald, 2006). The first known medical record was developed by Hippocrates in the fifth century B.C. and he prescribed two goals for such a record; to accurately reflect the course of a disease and to indicate the probable cause of disease (van Bemmel & Musen, 1997). These goals are still appropriate today (NIH NCRR, 2006). Studies observing physicians' use of the paper-based record find that logistical, organizational and other practical limitations reduce the effectiveness of traditional records for storing and organizing an ever-increasing number of diverse data. An EHR is designed to overcome many of these limitations and provide additional benefits that cannot be attained from a static view of events (Tang & McDonald, 2006).

EHR adoption is an important issue because firstly, many institutions would like to have EHRs in order to solve the logistic problem of the paper chart – cannot find the record, cannot find the particular items of information that are within it, cannot read it. Secondly, adopting EHRs can solve the problem in multi-site organizations where there is no way to move a paper chart to the multiple sites that require it. Thirdly, EHRs can provide aggregate information about patients for clinical research, outcomes management, process improvement and the development of new care products. Finally, EHR adoption will save money on paper storage, filing costs, and time spent on searching for physical records (McDonald, 1997), (Gunter&Terry, 2005). Overall, EHR adoption is seen worldwide as one method to reduce the widening gap between health care demand and supply (Ludwick & Doucette, 2009).

Nevertheless, despite all the potential benefits of EHRs, there has been some resistance to their adoption. The reason is twofold. Firstly, the sources of electronic patient information that do exist reside on many isolated islands that have been very difficult to bridge. Secondly, experts have not quite figured out how to capture the data from the

physician in a structured and computer understandable form and even with a single organization, many separate islands of information exist with different data structures. The external islands differ even more than those within a single institution. In other words, missing standards create interoperability problems (NIH NCRR, 2006), (McDonald, 1997). A possible solution to this standardization problem is buying all components from the same vendor but it came to light that these vendors had bought a series of smaller vendors and had not yet integrated disparate applications themselves (McDonald, 1997).

EHR Adoption Model

Kok, O., Basoglu, N., & Daim, T. (2011) proposed an EHR adoption model based on the studies of the Technology Acceptance model (TAM), and several other models.

TAM, proposed by Davis in 1989, is one of the most commonly used models to analyze the adoption of information technologies. Information technology, depending on its type, aims to improve users' performances, optimize the use of resources and maximize the outcome benefits. But experience shows that not every technology will be easily accepted by users. Researchers have addressed this issue by trying to understand users' behavior intentions: What drives them to use certain technology? Davis illustrated in the TAM model (Figure 2) that user motivations were perceived usefulness and perceived ease of use. Perceived usefulness refers to how the technology can help users improve their work performance. Perceived ease of use, on the other hand, represents how easily the technology can be used or operated by users. Obviously, users want the operations as simple as possible since it will save them time and enable them to be more productive. Therefore, perceived ease of use will, to some extent, also impact on perceived usefulness. Later on research defined several factors that would impact perceived usefulness and perceived ease of use, such as social impact, job relevance, gender, image, subjective norm, among others(Chuttur, 2009; Davis, 1989).



Figure 2 Technology Acceptance Model (Davis, 1989)

The EHR model proposed by Kok, O., Basoglu, N., & Daim, T. (2011) indicated that perceived usefulness, perceived ease of use and external factors are the motivators for the adoption intention. According to the model in figure 3, perceived usefulness is mainly influenced by quality of care, sharing, medical history and time saving. While, archiving, search ability, user interface and data preservation have significant effects on the perceived ease of use. As mentioned before, ease of use can also improve the usefulness of EHR systems towards users. External factors in their study included the legal influence and international standards issues. The following is the explanation of these factors. (Kok et al., 2011)

Factors impacting Perceived Usefulness

<u>Quality of care</u>: As one of the purposes for developing EHR system, quality of care is always a major concern for healthcare providers including physicians, nurses, administrators, and staff related to the system. Therefore, naturally the ability of EHR systems to improve the quality of health care has a positive effect on the perceived usefulness, which is also proved by many studies.

<u>Sharing</u>: In order to provide better patient care, physicians need to exchange their recorded information with others, which is also one convenience offered by EHR system. Therefore, speed, ease and more accuracy when sharing health records are the targets for an organization to improve their job performance. Standardization can enhance sharing. Additionally, according to our gap analysis, we found that people also concern of the privacy and security within the sharing process.

<u>Medical History</u>: Medical history records the detailed patients' health care information. It helps physicians know better about patients' history and thus will enable them give more accurate and more effective treatment to patients. More detailed and accurate medical history can improve physicians' performances.

<u>Time Saving</u>: The use of computer and advanced technology system is proven to reduce the time in terms of gathering, viewing and searching the healthcare record information compared to hand-written paper record system. Therefore, the more time is saved, the more useful the EHR system is.

Factors impacting Perceived Ease of Use

Compared to Perceived usefulness, ease of use is mainly from the technical perspective.

<u>Archiving</u>: In health care, the archiving is considered as the organized storage of patients' medical data or files. (Ruotsalainen et al., 2007)Document management is essential in the EHR system. Patients' medical history assists the health care providers to determine appropriate treatment plans. In order to achieve improved medical care records storage ability, a well-designed archiving system is a key. However, paper record is not a good way for archiving not only because that they are usually hand written which are not quite readable, but old records from long time ago also got lost easily. EHR Systems solve this issue. Taking advantage of computers, users can enter same information as before without extra time worrying about how to store them. Therefore, the more efficient and friendly archiving system is, the easier users will feel to use it. (Kok et al., 2011)

<u>Search Ability</u>: Search ability is another important system characteristic. Easy to find the required information is the popular demand by users and is the key to faster the treatment speed and the accurate information helps improve the treatment performance as well.

<u>User Interface</u>: Friendly user interface is the key for enabling the system is easy to use for users just like they can write anything they want on a paper sheet. And they can compare and analyze information easily as the way they used to.

<u>Data Preservation</u>: Long term preservation of records information is very important. It prevents from the inaccessible and lost records after a long term period. Keeping the records can reduce the cost and improve the health care performance sustainably. (BridgeHead Data, n.d.; Kok et al., 2011; Ruotsalainen et al., 2007)



Figure 3. EHR Adoption Model (Kok et al., 2011)

The purpose of our study is to analyze the current EHR adoption barriers in Oregon, adapt this model in Oregon EHR adoption and evaluate the model by studying how each factor affects users' decision to adopt the EHR systems.

Methodology

AHP, which we opted to use, is one of numerous multi-criteria decision-making methods. In order to solve a complex decision-making problem, AHP subdivides it into its components and arranges them into an ascending hierarchic order. At each level, the components are compared to each other using a pairwise comparison scheme. Components of a given level are then related to an adjacent upper level and thereby generate integration across the levels of the hierarchy. The result is a set of relative importance between entities. These relative priority weights can provide guidelines for the allocation of resources among the entities at the lower level (Saaty, 2005).

Implementation of AHP involved:

I. Structuring the EHR Adoption problem hierarchically as laid out below. This model is based on the Technology Acceptance model described in more detail in the EHR Adoption Model Section above.



Figure 4. AHP Model

II. Issuing a survey to capture expert judgment – pairwise comparisons and open ended questions. The survey was given to 12 health care practitioners that included a nurse, some dentists, an acupuncturist, a practicing dental student and some general practitioners from clinics and a number of hospitals. Qualtrics Online Survey was sent to potential respondents. For instance, in the sample below of the pairwise comparison for "usefulness" relative to "ease of use", respondents were required to move the slider to the desired point – if moved to the 60 point level then usefulness would be more important relative to usefulness and vice versa. These pairwise comparisons were carried out for each level of the hierarchy comparing each criterion against all its counterparts on the same level.



Figure 5. Qualtrics Pairwise Comparison Sample

Additionally, the open ended questions were as follows:

- Do you think that use of EHR system should be mandatory? Why or why not?
- Have you ever used an Electronic Health Record System?
- Which Electronic Health Record system have you used recently?
- Do you share electronic health records with your colleagues for consultation?

Finally, in order to capture the profile of the respondents, the latter were asked to answer the following questions:

- Age
- Gender
- Position (job)
- Years of working experience
- Years of experience with the EHR(Electronic Health Record) system (if applicable)
- III. Establishing the criterion considered most important to EHR Adoption, based on the responses from the survey. The results of the pairwise comparisons at each level of the hierarchy were entered into PCM software. This process is discussed in more detail in the Analysis section below.

Analysis and Discussion of the Proposed Model

For the analysis, first of all the team created a survey to send to practitioners who work in the health industry (See the appendix part for the survey.) The team received exactly 11 results out of 11 people. The respondents comprised a variety of people such as physicians, dentists, a clinic director, a general internist, an acupuncturist, and a practicing dental student. The following table shows the details; age, gender, occupation, years of working experience and year of experience with and EHR system; for each respondent.

Age	Gender	Occupation	Years of working experience	Years of experience with an EHR system
30's	male	physician	7	3
57	f	dentist	35	12
31	Female	Registered Nurse	7 months	4 years
43	female	physician	12	12
52	male	MD	25	5
43	female	Dentist	16	3
40	male	acupuncturist	5	2
35	female	clinic director	4	1
30	male	student	2	2
53	м	Physician (Internal Med/Hospitalist/ICU)	25	16+
41	female	general internist	12	14

Table 1. Respondants General Information

The survey includes 4 parts. In **Part 1**, the team compared the three main criteria impacting the adoption of EHR: **Perceived Usefulness**, **Perceived of Use**, and **External Factors** among themselves other as below:

- Perceived Usefulness vs. Ease of Use
- Perceived Usefulness vs. External Factors
- ✤ Ease of Use vs. External Factors

To calculate the weights for each comparison the team used PCM model. The first result that the team obtained for the relative weights of each factor above as below:

- Number 1 refers to Perceived Usefulness
- ✤ Number 2 refers to Perceived Ease of Use
- Number 3 refers to External Factors

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	Relative Weights Project Title: EHR_Intention	1
Users Person 1 Person 2 Person 3 Person 4 Person 5 Person 5 Person 7 Person 8 Person 9 Person 10 Person 11 Mean Min Max Std Dev	1 2 3 Incn 0.01 0.50 0.50 0.000 0.56 0.31 0.13 0.000 0.28 0.49 0.23 0.094 0.46 0.38 0.16 0.620 0.21 0.47 0.32 0.327 0.17 0.53 0.30 0.094 0.38 0.38 0.25 0.000 0.40 0.45 0.14 0.007 0.35 0.40 0.25 0.003 0.33 0.33 0.33 0.300 0.35 0.25 0.40 0.677 0.32 0.414 0.27 0.120 0.41 0.27 0.120 0.56 0.53 0.50 0.15 0.09 0.11	
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Figure 6.Original EHR adoption intention weights

However, the team realized that the inconsistency for person 5 (0.327) is high and thus, it is accepted as high inconsistency. Therefore, person 5 was excluded because inconsistency must never be greater than 0.1.

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	Relative Weights Project Title: EHR_EHR Adoption Intention	
Users Person 1 Person 2 Person 3 Person 4 Person 7 Person 7 Person 8 Person 10 Person 11 Mean Min Max Std Dev	1 2 3 Incn 0.01 0.50 0.50 0.000 0.56 0.31 0.13 0.000 0.28 0.49 0.23 0.094 0.46 0.38 0.16 0.020 0.17 0.53 0.30 0.094 0.38 0.38 0.25 0.000 0.40 0.45 0.14 0.007 0.35 0.40 0.25 0.003 0.33 0.33 0.33 0.300 0.35 0.25 0.40 0.067 0.33 0.40 0.27 0.124 0.01 0.25 0.13 0.56 0.53 0.50 0.15 0.09 0.12	
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Figure 7. Actural EHR adoption intention weights

Since the **Perceived Ease of Use** has the highest weight (0.4), it is the most important factor impacting the adoption of EHR. The following chart shows the percentage distribution of the main factors.



Figure 8. The contribution percentage of usefulness, ease of use and external factors.

In **Part 2**, the subcriteria of the three main factors explained in Part1 were compared respectively. Firstly, the team started to compare with **the subcriteria of Perceived Usefulness** among themselves as the following:

- ✤ Quality of Care vs. Sharing
- Quality of Care vs. Medical History
- ✤ Quality of Care vs. Medical History
- ✤ Sharing vs. medical History

- ✤ Sharing vs. Time Saving
- ✤ Medical History vs. Time Saving

After the above comparison, the first result the team obtained for the relative weights of each subcriteria is as in the below table. It includes the relative weights of the subcriteria of Perceived Usefulness.

Here, the team realized much higher inconsistencies of 0.209 and 0.287.

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ſr	Relative Weights	1
	Project litle: EHK_Usefulness	
Users	1 2 3 4 Incn	
Person 1	0.18 0.13 0.40 0.28 0.042	
Person 2	0.35 0.19 0.32 0.15 0.007	
Person 3	0.55 0.18 0.25 0.01 0.209	
Person 4	0.37 0.21 0.27 0.13 0.002	
Person 6	0.00 0.20 0.14 0.57 0.034	
Person 7	0.30 0.28 0.32 0.05 0.287	
Person 8	0.24 0.11 0.24 0.40 0.035	
Person 9	0.32 0.26 0.26 0.16 0.027	
Person 10	0.25 0.25 0.25 0.25 0.000	
Person 11	0.36 0.32 0.16 0.16 0.086	
Mean	0.29 0.21 0.27 0.22 0.112	
110		
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ocu Dev	0.12 0.00 0.00 0.10	
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Figure 9. Original EHR Percevied Usefulness weights

So, the team removed person 3 and 7 from the data. The final results for the subcriteria of Perceived Usefulness are as below.

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Users Person 1 Person 2	Relative Weights Project Title: EHR_Percevied Usefulness 1 2 3 4 Incn 0.18 0.13 0.40 0.28 0.042 0.35 0.19 0.32 0.15 0.007	
Person 4 Person 5 Person 6 Person 8 Person 9 Person 10 Person 11	0.37 0.21 0.29 0.13 0.002 0.20 0.21 0.28 0.30 0.012 0.09 0.20 0.14 0.57 0.034 0.24 0.11 0.24 0.40 0.035 0.32 0.26 0.26 0.16 0.027 0.25 0.25 0.25 0.25 0.000 0.36 0.32 0.16 0.16 0.086	
Mean Min Max Std Dev	0.26 0.21 0.26 0.27 0.100 0.09 0.11 0.14 0.13 0.37 0.32 0.40 0.57 0.10 0.06 0.08 0.14	
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Figure 10. Actual EHR Percevied Usefulenss weights

After that, the team had one more step to calculate the normalized values. For this, the main criterion (Perceived Usefulness) was multiplied with each of its sub criteria as below:

Usefulness	Subcriteria respectively	Results	
0.33	0.26	0.0858	Quality of Care
0.33	0.21	0.0693	Sharing
0.33	0.26	0.0858	Medical History
0.33	0.27	0.0891	Time Saving

Table 1. Final factor weight results for Usefulness subcriteria

Time Saving by a small margin got the highest percentage in the 'Usefulness' category, however, it's score is very close to Quality of Care and Medical History. Medical History (recording patients' health care information) and Quality of Cares show equal percentages in importance for Perceived Usefulness and the team considered those factors important subcriteria. The distribution didn't show a single factor stand out, since all the weights are in the 20s. The lower score was for Sharing, but it was not really low enough to discount the importance of this subcriteria.

To continue Part 2, secondly, **the subcriteria of Perceived Ease of Use** were compared among themselves respectively as below:

- ✤ Archiving vs. Search Ability
- ✤ Archiving vs. User Interface
- ✤ Archiving vs. Data Preservation
- Search Ability vs. User Interface
- Search Ability vs. Data Preservation
- ✤ User Interface vs. Data Preservation

The first result the team obtained for the relative weights of each subcriteria as in the below table. It includes the relative weights of subcriteria of Perceived Ease of Use factor. As well as in the previous comparisons, the team found very high consistencies again and excluded them. They are respectively 0.243 (person 3), 0.123 (person 4), and 0.103 (person 7).

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	Relative Weights Project Title: EHR_Ease of Use	
Users Person 1 Person 2 Person 3 Person 4 Person 5 Person 6 Person 7 Person 7 Person 9 Person 10 Person 11 Mean Min Max Std Dev	1 2 3 4 Incn 0.20 0.25 0.31 0.25 0.021 0.18 0.31 0.30 0.21 0.009 0.36 0.45 0.05 0.14 0.243 0.29 0.25 0.30 0.16 0.123 0.28 0.28 0.23 0.22 0.008 0.22 0.25 0.38 0.25 0.005 0.60 0.32 0.07 0.01 0.103 0.16 0.37 0.32 0.16 0.095 0.16 0.37 0.32 0.16 0.005 0.16 0.37 0.32 0.16 0.005 0.16 0.37 0.32 0.16 0.005 0.16 0.32 0.16 0.005 0.01 0.15 0.38 0.27 0.20 0.021 0.26 0.30 0.24 0.21 0.104 0.60 0.45 0.32 0.46 0.038 0.13 0.08 0.09 0.11	
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Figure 11. Original EHR Percevied Ease of Use weights

This below table shows the results of the subcriteria of Perceived Ease of Use after being deleted high

inconsistencies.

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Users Person 1	Relative Weights Project Title: EHR Perceived Ease of Use 1 2 3 4 Incn 0.20 0.25 0.30 0.25 0.021	
Person 2 Person 5 Person 6 Person 8 Person 9	0.18 0.31 0.30 0.21 0.009 0.28 0.28 0.23 0.22 0.008 0.22 0.25 0.28 0.25 0.005 0.16 0.37 0.32 0.16 0.005 0.18 0.16 0.20 0.46 0.038	
Person 10 Person 11 Mean Min Max Std Dev	0.25 0.25 0.25 0.25 0.000 0.15 0.38 0.27 0.20 0.021 0.20 0.28 0.27 0.25 0.065 0.15 0.16 0.20 0.16 0.28 0.38 0.32 0.46 0.04 0.07 0.04 0.09	
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Figure 12. Actual EHR Percevied Ease of Use weights

To find the normalized values of the subcriteria of Perceived Ease of Use:

Ease of Use	Subcriteria respectively	Results]
0.40	0.20	0.0800	Archiving
0.40	0.28	0.1120	Search Ability
0.40	0.27	0.1080	User Interface
0.40	0.25	0.100	Data Preservation

Table 2. Final factor weight results for Ease of Use subcriteria

In this table, the team specified interesting results since three weights of subcriteria are very close to each other. So, the team decided that the respondents think that **Search ability, User Interface,** and **Data Preservation** are together important to Perceived Ease of Use. In other words, in EHR system, the respondents think that:

- finding the required information easily in terms of accurate information and speeding up the treatment
- writing anything they want on a paper and comparing/analyzing information easily
- preventing from inaccessible and lost records after a long time period and reducing the cost and improving the health care performance by keeping records

are more significant than Archiving.

The last comparison in Part 2 is the comparing the **subcriteria of External Factors** among themselves as the following:

- Cost vs. Legal / Policy
- ✤ Cost vs. Training
- ✤ Legal Policy vs. Training

The first result of the comparison of each subcriteria is in the following table below. Any high consistency was not found for this comparison. When the team saw the total results of weights of main factors, they realized that it does not add up 1 because the software rounded the numbers. To make it add up to 1, the team calculated the values in Excel to specify the unrounded numbers. The following table shows this calculation in detail. The final results for the subcriteria of External Factors are in the following table:

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	Relative Weights Project Title: EHR External Factors	
Users Person 1 Person 2 Person 3 Person 5 Person 7 Person 7 Person 9 Person 10 Person 11 Person 4 Mean Min Max Std Dev	1 2 3 Incn 0.42 0.37 0.21 0.005 0.25 0.47 0.29 0.014 0.60 0.24 0.16 0.000 0.19 0.61 0.21 0.020 0.30 0.28 0.42 0.004 0.64 0.10 0.26 0.056 0.50 0.29 0.21 0.009 0.33 0.33 0.33 0.000 0.54 0.29 0.17 0.001 0.00 0.00 0.00 0.000 0.41 0.32 0.26 0.129 0.19 0.10 0.16 0.64 0.61 0.42 0.15 0.14 0.09	
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Figure 13.EHR External factors weights

When the team saw the total results of weights of main factors, they realized that it does not add up 1 because the software rounded the numbers. To make it add up to 1, the team calculated the values in Excel to specify the unrounded numbers. The following table shows this calculation in detail. The final results for the subcriteria of External Factors are in the following table:

1.00

	External Factors		
	Cost	Training	Legal/Policy
Person 1	0.42	0.37	0.21
Person 2	0.25	0.47	0.29
Person 3	0.6	0.24	0.16
Person 5	0.19	0.61	0.21
Person 6	0.3	0.28	0.42
Person 7	0.64	0.1	0.26
Person 8	0.5	0.29	0.21
Person 9	0.35	0.27	0.37
Person 10	0.33	0.33	0.33
Person 11	0.54	0.29	0.17
	0.412	0.325	0.263
	0.41 0.33 0.26		

Table 3. External Factors weights calculation

To calculate the normalized values:

External Factors	Subcriteria respectively	Results	
0.27	0.41	0.1107	Cost
0.27	0.33	0.0891	Training
0.27	0.26	0.0702	Legal/Policy

Table 4. Final factor weight results

Obviously, **Cost** is the most important factor subcriteria of External Factors. So, this means that according to the respondents, Cost (for up-front purchase cost, maintenance cost, training cost and upgrading cost) is the one that impacts the adoption of EHR. This result was expected.



The chart below shows the percentage distribution of all subcriteria.

Figure 14. Distribution of all subcriteria

The part 3 includes four verbal questions related to EHR system.

1. Do you think that the use of an EHR system should be mandatory? Why or why not?

We received the following answers from the respondents:

- Respondent 1= Yes, reduced time spent information search and management, reduced errors and improved outcomes with its use.
- Respondent 2= Mandotory in what settings? I think overall yes, for all of the reasons thay you just asked about on the previous two pages.
- ✤ Respondent 3= I think it should be the mandotory because it saves time, thus patient care is fast and efficient.

- Respondent 4= Yes, probably, altought it shifts the burden of clerical work to physicians so impairs our productivity.
- Respondent 5= Yes
- Respondent 6= Yes, faster and more comprehensive record sharing for optimum patient treatment.

So, based on the results above for the first question, the team interpreted that each respondent think that EHR sytem definetely must be mandatory in terms of reducing time spent and errors, improving the outcomes, saving time, helping to provide an optimum patient treatment and improving productivity.

2. Have you ever used an Electronic Health Record System?

All respondents answered, "Yes".

3. Which Electronic Health Record system have used recently?

- ✤ Respondent 1 used EPIC
- Respondent 2 used Dental
- ✤ Respondent 3 used BIORAC and EPIC
- Respondent 4 used Epiccare (Health Connect) and Portal
- Respondent 5 used EPICARE
- Respondent 6 Eaglesoft
- Respondent 7 used WUFOO
- ***** Respondent 8 did not answer this question.
- Respondent 9 used AXIUM
- Respondent 10 used EPIC
- Respondent 11 used EPIC



Figure 15. Summary of the EHR systems used by the respondants

As seen above, there are several different EHR sytems by used the respondents and it looks like **EPIC** sytem is more popular among the respondents such as respondent 1, respondent 3, respondent 10 and respondent 11.

4. Do you share electronic health records with your colleagues for consultation?

10 respondents answered, "Yes" and 1 respondent "NO."

In part 4 the respondents were asked to answer general demographic questions.

The results for these questions are already shown at the beginning of the analysis and discussion part.

During an informal conversation with one of the experts who agreed to participate in the online questionnaire, certain concerns towards EHR were strongly noted. Some of them were:

- Doctors are not used to lengthy record-keeping practices the job of entering information in the computer as opposed to writing a quick note and passing it to the filing clerk, an administrative assistant or a nurse for record keeping is convenient. Doctors perceive that they are doing more administrative assistant work with EHR.
- Some specific user interface changes requested by doctors like increasing the size of a clickable button are usually perceived as not important by system engineers. Customization is important for doctors.

• Since some large-scale, hospital EHR require significant investments whether its money, training, time etc., it can become difficult to switch to a different EHR system even though it may better fit the needs of the doctors – they might be just stuck with the existing one.

Conclusions

This study extends the work reflected in EHR adoption model developed by Kok, O., Basoglu, N., & Daim, T. (2011). The success factors: quality of care, sharing, medical history, time saving, archiving, search ability, user interface and data preservation, cost, training, legal/policy and their impacts on EHR system's adoption have been analyzed with the AHP model and evaluated with the help of the expert judgment questionnaire and with calculations performed with the help of PCM software and Excel . These success factors have a major influence on the main factors, Perceived Usefulness, Perceived Ease of Use and External Factors. And, all this subcriteria factors and main factors affect Behavioral Intention.

We selected a team of experts (doctors) and created an online questionnaire on Qualtrics to understand which main factors influence Behavioral Intention. According to the results of the expert judgment through the methodology of pairwise comparisons and calculations, Perceived Ease of Use is the most important factor overall. This information could be uplifting to the software and system developers since they could directly influence positive changes in this factor. Search Ability, User Interface and Data Preservation are almost equally important factors overall and in the Perceived Ease of Use category with Search Ability and User Interface being the top two. Cost was a #2 importance factor overall and #1 in the External factors category. It was surprising to see Training being a less important factor in comparison to Cost. According to the expert judgments, Medical history (recording patients' health care information) and Time Saving (reducing the time in terms of gathering, viewing and searching the healthcare record information) and Quality of Care are more important subcriteria for Perceived Usefulness. All experts agreed that EHR adoption should be mandatory. The results of the calculations are displayed in the figure below:



Figure 16. Summary of final results in AHP model.

Limitations and Future Research

We have looked at the EHR adoption trying to capture perceptions of doctors, while there are other stakeholders who might have different views on the importance of the criteria examined. For example, one might look at the perceptions of patients or hospital administrators or software developers.

The experts used in this study reflected the views of various hospitals and clinics in Portland Metro area. Such study could be duplicated in other cities/geographic locations or could be conducted on a national level.

Administrators might have a better view of the external factors in the model, therefore, more factors and their importance could be examined or a separate study on the influence of external environment could be conducted.

It would be interesting to explore peer-to-peer and physician networks influences on system adoption and try to incorporate those into the model since the literature (Anderson et al. ed., 1994), (Zheng et. al., 2007)shows that they have impacts on technology adoption.

The questionnaire gathered some information about the software used in the industry since the respondents were asked to provide what EHR system they are currently using. Future study could be done to explore and evaluate those EHR systems.

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Appendix

[PDF files of the online survey provided separately]