



Psychological and Intuition Requirements for more attractive Electronic Health Records

Requisitos Psicológicos e Intuitivos para Prontuários Eletrônicos do Paciente mais atraentes

Requisitos Psicológicos y Intuitivos para Registros Electrónicos de Paciente más atractivos

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ABSTRACT

Keywords: Electronic Health Records; Software Engineering; Psychologic Processes

Objective: To report on an investigation of requirements, with focus on Psychological and Intuition Requirements (PIRs), to make adoption of Electronic Health Records (EHRs) more encompassing and expeditious. **Methods:** The investigation collected EHR features from the literature, commercially available EHR software and proposed EHR standards. By using a mix of a modified Delphi method, a questionnaire-based survey, and interviews with EHR developers and usage stakeholders, the investigation: 1) classified requirements of EHRs; 2) ranked resulting classes by their importance for EHR adoption; and, 3) analysed whether PIRs were in the most important classes. **Results:** Ten EHR requirements classes were elicited and had different concentrations of PIRs. PIRs were proven useful for EHR adoption, but standards should be also reinforced. Functional requirements had smaller importance. **Conclusion:** PIRs from security and ease of use classes should have higher priority in EHR development, maintenance, and evolution to ease adoption.

RESUMO

Descritores: Prontuários Eletrônicos de Paciente; Engenharia de software; Processos psicológicos

Objetivo: Relatar sobre investigação de requisitos, com foco em Requisitos Psicológicos e Intuitivos (RPIs), para aumentar e acelerar a adoção de Prontuários Eletrônicos de Paciente (PEP). **Métodos:** A investigação coletou características PEP da literatura, software PEP comercial e padrões PEP. Combinando um método Delphi modificado a uma pesquisa com questionário e entrevistas com desenvolvedores e outras partes interessadas em PEP, a investigação: 1) classificou requisitos PEP; 2) ordenou as classes resultantes por importância para adoção de PEP; e 3) analisou se os RPIs estavam nas classes mais importantes. **Resultados:** Dez classes de requisitos PEP foram extraídas e tiveram diferentes concentrações de RPIs. Os RPIs se mostraram úteis para a adoção de PEP, mas deve-se também, reforçar padrões. Os requisitos funcionais tiveram menor importância. **Conclusão:** RPIs das classes de segurança e facilidade de uso devem ser priorizados no desenvolvimento, manutenção e evolução de PEP para facilitar adoção.

RESUMEN

Descriptores: Registros de salud electrónicos; Ingeniería de software; Procesos psicológicos

Objetivo: Informar sobre la investigación de requisitos, con enfoque en Requisitos Psicológicos y Intuitivos (RPIs), para aumentar y acelerar la adopción del Registro Electrónico de Pacientes (REP). **Métodos:** La investigación recolectó características REPs de la literatura, software comercial y estándares REPs. Combinando un método Delphi modificado con un cuestionario y entrevistas con desarrolladores y otras partes interesadas en REPs, la investigación: 1) clasificó requisitos REP; 2) clasificó las clases resultantes por importancia para adopción de REPs; y 3) analizó si RPIs estaban en las clases más importantes. **Resultados:** Se obtuvieron diez clases de requisitos REPs y tuvieron diferentes concentraciones de RPIs. RPIs han demostrado ser útiles para la adopción de REPs, pero los estándares también deben ser reforzados. Los requisitos funcionales fueron menos importantes. **Conclusión:** RPIs de las clases de seguridad y facilidad de uso deben priorizarse en el desarrollo, mantenimiento y evolución de REPs para aumentar la adopción.

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INTRODUCTION

Electronic Health Records (EHRs) are Information Systems (IS) that manage evidence on patients' health to support decisions and actions by healthcare professionals⁽¹⁾. EHRs promise to improve efficiency and quality of healthcare by increasing users' productivity, reducing costs, and even saving lives. Yet, EHR adoption is still low and slow, mainly because of poor user experiences.

In late 2016, despite incentives, adoption rates were around 35% in the USA, and just 3% in Europe⁽²⁾. Even recently, few physicians run EHRs in their offices and not many hospitals run a basic version of an EHR platform⁽³⁾. Users' demand for change or upgrade of existing EHR versions remains consistently high⁽⁴⁾. This demand is difficult to be met by global providers, particularly if it comes from small practices with little financial clout, in less-developed countries. In the case of Brazil, for instance, small clinics often contract EHR solutions from young software houses, which tend to respond more quickly and affordably to change demands. The problem in such cases is the prioritisation of EHR requirements. This paper investigates EHRs in the context of IS engineering to help identify and prioritise requirements that will make EHR adoption more encompassing and expeditious.

A large body of the literature on IS for healthcare deals with research on EHR requirements. Such research should gain renewed interest spurred by integration needs and the spread of telehealth prompted by the Covid-19 pandemic⁽⁵⁾.

Major barriers to EHR adoption and evolution stem from unsatisfactory user's experiences, lack of interoperability, and difficulty of use amongst major complaints⁽⁶⁾. Other non-technological reasons for low EHR adoption are psychological, such as the expectation of performance and effort⁽⁷⁾, the poor mapping of effects from users' exposure to customary practice procedures, and EHR's look-and-feel.

A recent paper on EHR access options indicated touch screen as the preferred input device⁽⁸⁾, likely motivated by ubiquitous and familiar smart phones. Also, healthcare professionals who worked with paper-based records might expect EHRs will function equivalently. This may be explained by the Mere Exposure Effect – MEE⁽⁹⁾, which states that one prefers what one is accustomed to. For instance, some clinicians may intuitively ponder a patient's health by considering physical characteristics of paper records.

In this paper, we assume that users' expectations map into Psychological and Intuition Requirements (PIRs). We define a PIR as a software requirement that promotes a good fit between the software user's expectation of a specific utility. It is also suggested that PIRs emerge from the implementation of metaphors or familiar elements, which tend to depend on the task at hand⁽¹⁰⁾. This paper deals with requirements from healthcare practitioners and their level of familiarity with the EHR when migrating from paper records – e.g., if usage stains on portions of a paper-based record serve to signal when the patient's health worsened, the EHR interface should reflect that. We also expect that values for PIRs' attributes change dynamically with EHR usage - e.g., the shade of grey of the EHR illustrated in Figure 1 should darken as pages are manipulated.

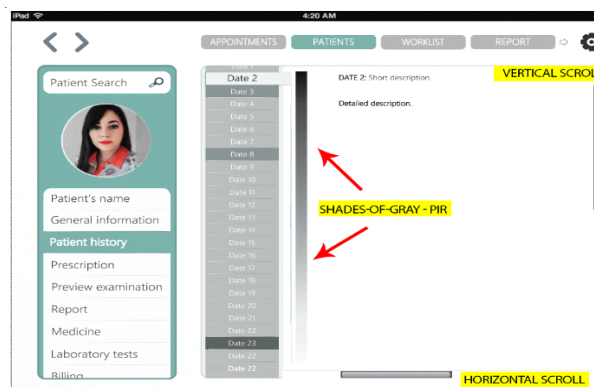


Figure 1 - Shades of grey to signal an EHR's portions with high usage

Previous research⁽¹¹⁾ applied the Delphi method to examine variation in the adoption of “basic” and “fully” functional EHR versions and their use patterns, barriers to adoption, and perceived benefits by physician practice size. Also, EHR adoption characteristics (Usability; Functionality; Security; and, Privacy and Confidentiality) have been identified⁽¹²⁾ but not ranked by importance. Research has also found that EHRs produce negative (e.g, interruption of workflow) and positive (e.g, documentation quality) feelings but not all EHR functions are fully used⁽¹³⁾. Psychological aspects have not been explicitly addressed in the literature. Thus, there are two problematic gaps in the literature: one, the characteristics of PIRs and two, the ranking of these characteristics according to importance to EHR adoption.

The problem addressed by our paper is the understanding of PIRs' role in closing these two gaps – i.e., whether PIRs facilitate successful usage of EHRs and the importance they could have for requirements of EHR software development. The objectives of the investigation consist of answering two research questions (RQs): **RQ1** - What are the requirements that facilitate EHR adoption? and, **RQ2** – Do the requirements that are ranked most important for easing EHR adoption have higher concentrations of PIRs?

In order to answer the two RQs, we used a research methodology that first, collected EHR features from the literature, commercially available EHR software and proposed EHR standards; and, then, classified and ranked collected requirements by using a mix of a modified Delphi method, a questionnaire-based survey, and interviews with EHR developers and stakeholders.

Results indicated that PIRs are important for EHR adoption and that security and ease-of-use related PIRs should have higher priority for EHR development, maintenance, and evolution of early versions.

The remainder of the paper is organised as follows. Section 2 summarises the four-step methodology used to answer the research questions. Section 3 presents and discusses results for each of the four methodological steps. Section 4 wraps up the paper with conclusions and suggestions of future work. More details about each of the following sections can be found in the external repository [here](#).

METHODS

In order to address RQ1 and RQ2, our four-step

methodology (Figure 2): sought to:

- i) Identify and classify requirements of EHRs in general.
- ii) Rank requirements classes according to their importance for EHR adoption; analyse class dependence on PIRs – if more important classes are also of a psychological nature that is evidence PIRs make EHRs more attractive.

In step 1, MEE served as a background to discuss PIRs within EHR requirements classes, which are harvested from the literature, analysis of the Healthcare Information and Management Systems Society's (HIMSS) Analytics Electronic Medical Record Adoption Model (EMRAM)⁽²⁾, evaluation of EHR software packages, and by examining a proposed standard as base for EHRs in Brazil.

Step 2 used a panel of experts in a two-round, modified Delphi method to initially validate and rank elicited EHR requirements classes and to check the step 3 survey questionnaire. Experts were selected through a non-random, purposive sampling⁽¹⁴⁾. They also needed to be peer-physicians (to reduce embarrassment in round 2) and should use EHRs extensively. Requirements classes are also examined for consistency with software quality-influencing characteristics of ISO/IEC 25010 (iso25000.com).

In step 3, sixteen nurses and eleven physicians, in active practice and EHR usage at the medical school clinic of the Faculty of Medical Sciences (FCM) in Campina Grande, PB, Brazil, answered the questionnaire. A few initial participants suggested others by snowballing⁽¹⁴⁾. The research method chosen was a structured questionnaire-based cross-sectional survey, which had an open question about requirements classes, and, the list of classes to be ranked in decreasing order of importance for EHR adoption (the most important class being #1). The statistical computation tool R (www.rstudio.com) was used to quantitatively consolidate the ranks for a given requirements class, using the following: the arithmetical average (mean) of the ranks (AAIR); AAIR adjusted for uncertainty, AAIRU (i.e., AAIR times the variance of the given class' ranks); the mode; and, the median.

Step 4 used open-ended questions-driven interviews for a qualitative assessment of findings by four EHR stakeholders: one dentist at a private clinic and one small polyclinic CEO (who also performs health care) – both responsible for interacting with EHR providers; and, two

software engineers with experience in developing customised EHRs for small practices. None of these stakeholders took part in previous steps of the methodology.

Prior to the recruitment of any participant, ethical approval was received from Unifacisa University's Research Ethics Committee, Campina Grande, PB, Brazil, under Number 2.284.495. No participant was compensated financially or otherwise.

RESULTS AND DISCUSSION

Sep 1 - EHR requirement classes

Ten EHR requirements classes were elicited from step 1 sources documentation and analyses of standards' and EHR software features (Table 1). More details [here](#).

In order to ease EHR adoption, PIRs should transverse each Table 1 class to a larger or smaller extent. As shown in Table 1, it is more natural to implement PIRs in CEU than in INT or SUP, since there are fewer effects of exposure to integration and support towards paper records. Considering this, it is expected that paper records' lack of integration leads to an enhanced perception of security (SEC). Classes ADT, CON, QUA, PER and FUR have weak dependence on the exposure effect since they might not be coded to mimic how healthcare professionals perform tasks. On the other hand, these classes, in particular ADT and FUR, are linked to the perception of usefulness and could benefit from being coupled with MEE-based PIRs in their implementations. This could aid on making EHRs more attractive to users, as intended with the satisfaction and functional appropriateness factors of ISO/IEC 25010's dimensions of product quality and quality in use.

We thus characterise the classes' dependence on PIR content to ease EHR adoption as (more details in the external repository [here](#)):

- High PIR content: CEU and SEC.
- Medium PIR content: ADT, COS and FUR.
- Little PIR content: PER, INT, QUA, CON and SUP.

Step 2 - preliminary ranking of EHR requirements

Step 2 evolved around unstructured interviews of the three panellists: an endocrinologist, a gynaecologist, and a pharmacologist, each with over 10 years of practice. The interviewees were invited to rank each requirements class

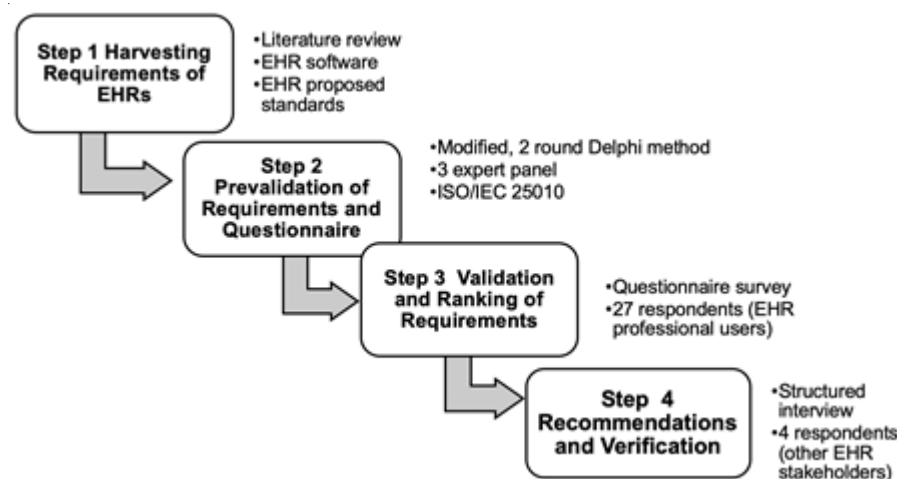


Figure 2 - Methodology steps

Table 1 - EHR requirements classes (alphabetical order).

Requirement Class	Description
ADT - Adequacy to Tasks	Adequacy to healthcare professionals' needs, practices and methods. Flexibility to accommodate a comprehensive spectrum of clinical and non-clinical healthcare domains.
CEU - Comfort and Ease of Use	An EHR should be readily usable and comfortable to use. Its interface should allow for freedom of annotation of information (e.g., drawings, exams – including images, videos, and audio); and, for hints on the patient's health from EHR characteristics (size, frequency of access, look & feel of paper records, etc.) so that professionals satisfactorily perform tasks in an effective and efficient manner as indicated by the HIMSS EMR Adoption Model.
CON – Concentration	An EHR should facilitate users to concentrate attention on the patient.
COS - Compatibility with Standards	With government-, medicine council- or World Health Organization-set standards – such as HL7 (www.hl7.org), ICD-11 (icd.who.int), openEHR (www.openehr.org), SNOMED (www.snomed.org), independently of provider.
FUR – FUnctional Requirements	Richness of functional facilities and resources to make the anamnesis and information retrieval (e.g., lab exams, prescriptions, procedures, or protocols) more efficient and appropriate for the medical specialisation at hand.
INT – INTegration	Integration of data to other systems' repositories while ascertaining data authenticity, confidentiality, and integrity.
PER - PERformance Requirements	Essentially non-functional, qualitative requirements related to performance such as the speed of execution or the precision of the data that are returned to the user.
QUA – QUALity	Assistance in keeping the quality of patient care by supporting policies for processes, norms and good practices, reuse of services, and ease of maintenance.
SEC – SECurity	Secure information against unauthorised third-party access.
SUP – SUPport	Availability of technical support, maintenance, training and installation services.

according to their perceptions of the importance whilst migrating from paper records to EHRs. Participants were not aware of PIRs' role in this case. Findings from their comments:

- a) Paper records facilitate attention on the patient because it is easier to write than handle a new interface and, advanced searches require technical support with a long turnaround time.
- b) Standards should be enforced to ease EHR migration. For that, a small set of core functions and features should be implemented in the beginning, i.e., version 1 (“basic v1”).
- c) Classes in Table 1 seemed appropriate for the study.

The questionnaire was deemed adequate.

d) The panel in round 2 reached consensus on the following ranking order

1-SEC/2-CEU/3-CON/4-QUA/5-PER/6-SUP/7-COS/8-ADT/9-INT/10-FUR

Step 3 results - rankings of EHR requirements classes

Respondents were 67% males and 33% females with ages as plotted in Figure 3. All nurses had graduate degrees and 37% of the physicians were in General Practice at FCM in Brazil. All respondents had been using EHRs from

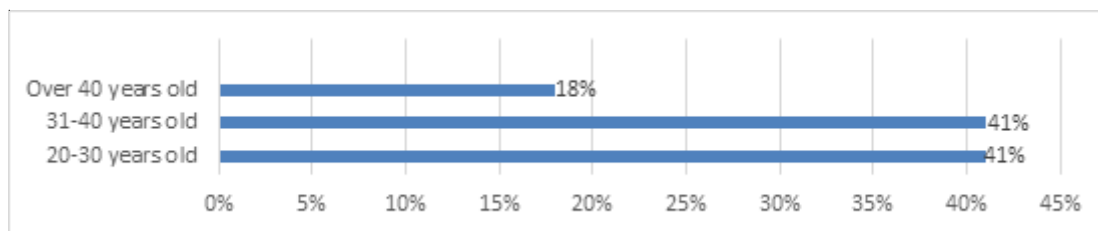


Figure 3 - Age distribution of respondents of questionnaire in step 3.

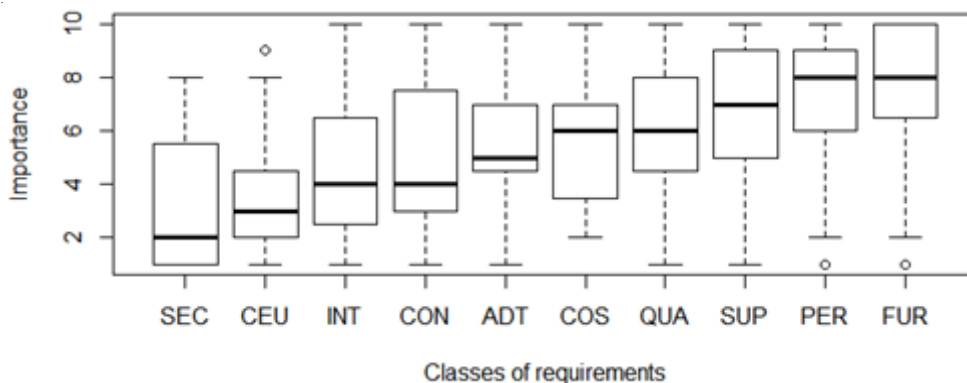


Figure 4 - Boxplot graph (minimum, first quartile, median, third quartile, and maximum) for the rankings of the EHR requirements classes

2 to 5 years.

By using the median, SEC and CEU rank 1st and 2nd in importance (Figure 4).

Rankings with other criteria were extracted from Table 2 as it follows:

- Using the mode:

1-SEC/2-CEU/3-ADT/4-INT/5-CON/6-COS/7-SUP/8-QUA/9-NRF/10-FUR.

- Using AAIR:

1-SEC/2-CEU/3-INT/4-ADT/5-COS/6-CON/7-QUA/8-SUP/9-PER/10-FUR.

- And adjusting for uncertainty, AAIRU:

1-CEU/2-SEC/3-COS/4-CON/5-INT/6-QUA/7-ADT/8-PER/9-SUP/10-FUR.

All rankings yield SEC and CEU, which are classes with higher PIR concentration, as the most important classes. From the order rankings, it is possible to make a few observations.

First, the preliminary ranking by the experts in the trial run (step 2) matches those of the 27 respondents at the top two places and the bottom (10th) one overall.

Second, AAIRU puts CEU as more important than SEC (Table 2). The importance of CEU has the least amount of uncertainty: its variance is the lowest; or equivalently, its 26 degrees of freedom, 95% confidence interval for the mean is the shortest ($\pm 24.28\%$ of mean versus $\pm 29.40\%$ for SEC; Table 2). Further, only the upper 12.43% of CEU's 95% confidence interval for its mean is outside (higher than) that of SEC's; the rest is within the interval of SEC. This implies that CEU can be ranked first, as the ordering by AAIRU suggests.

Third, it is important to notice the outlier for CEU (rank 9th attributed by a single respondent) and CEU's narrower interval than SEC's in Figure 4. This signals uncertainty in relative order ranking between SEC and CEU; indeed, AAIRU puts CEU as more important than SEC (see Table 2). However, the importance of CEU presents the least amount of uncertainty by the respondents: its variance is the lowest; or equivalently, its 26 degrees of freedom, 95% confidence interval for the mean is the shortest ($\pm 24.28\%$ of mean versus $\pm 29.40\%$ for SEC – Table 2). Further, only the upper 12.43% of CEU's 95% confidence interval for its mean is outside (higher than)

that of SEC's; the rest is within the interval of SEC. This implies that CEU can be ranked first, as implied by AAIRU. CEU is likely the requirement class with the densest concentration of PIRs.

Fourth, Figure 4 also shows an outlier for PER and another for FUR classes; this is represented by one vote each for 1st place (most important class) out of 27 possible votes.

Fifth, FUR, which was expected to have an “ease of migration” perspective, ranks last in all rankings thus correlating with “basic v1” in point b) of step 2. “Basic v1” and the 4th observation might signal shifts in importance as versions evolve (see section 3.5).

Sixth, point a) in step 2 associated “quality” to “ease of use”. We presumed that ease of use was a characteristic equivalent to familiarity with the EHR look and feel. In order to verify that, we tested the correlation between SEC (high PIR concentration) and QUA by running the Kruskal-Wallis Test⁽¹⁵⁾ with the null hypothesis (H0) being that there was correlation between SEC and QUA.

Hence, at 0.05 level of significance, there was no evidence to refute H0 (hence H0 holds). This means that quality and familiarity (brought about by PIRs) are, in fact, correlated.

The above observations provide evidence that PIRs are key success factors for faster adoption of an EHR (affirmatively answering RQ2). Thus, development, maintenance and evolution of EHRs should prioritise security and ease of use.

Step 4 results - assessment of findings

Taken together, the four interviewees (two practitioners and two software developers) totalled over 30 years' experience with EHRs:

- The first practitioner has been in practice since 2000 at a small clinic. At first, loose digital files with patients' information were used, which were then moved to an EHR from a major provider. Since 2014, an EHR developed and maintained by a small software house has been in operation.

- The second practitioner is a CEO of a polyclinic with 15 medical specialisations, imaging exams and laboratory. This practitioner has over 5 years' experience in healthcare and has been trying to deploy a simple EHR that would fit most specialisations' needs with an “intuitive interface”. Major EHR

kruskal-wallis rank sum test

data: quality by facility

kruskal-wallis chi-squared = 6.8128, df = 7, p-value = 0.4486

Table 2: Rankings according to different criteria

Class	Mode	Median	AAIR	95% Cfd. Int.	Variance	Std. Dev.	AAIRU
SEC	1	2	3.18	[2.25;4.12]	5.62	2.37	17.89
CEU	2	3	3.48	[2.64;4.33]	4.57	2.14	15.89
ADT	4	4	5.04	[3.87;6.20]	8.73	2.95	43.97
INT	4	4	4.59	[3.48;5.70]	7.87	2.80	36.12
COS	6	6	5.48	[4.60;6.36]	4.95	2.22	27.14
CON	5	5	5.67	[4.75;6.58]	5.38	2.32	30.51
QUA	8	6	5.96	[4.91;7.01]	7.04	2.65	41.96
SUP	7	7	6.48	[5.34;7.62]	8.26	2.87	53.53
PER	8	8	7.29	[6.32;8.28]	6.14	2.48	44.79
FUR	10	8	7.41	[6.33;8.48]	7.40	2.72	54.85

providers were ruled out due to price and inflexibility to implement required features. A freelance software engineer developed an “embryonic EHR” with a simple interface “shell” that integrates patient data from digital document and spreadsheet files as in “paper records”.

- One of the software engineers is a leader of a 5-member software development team that has been developing EHRs since 2019. The team has developed an EHR for small clinics that manages meds and allows individual patient access to her/his own customisable profile through a mobile app. At the time of the interview, the team was working on the introductory version of a gamified EHR that helps patients and psychologists undergo and monitor respectively, Cognitive-Behavioural Therapy.

- The other interviewed engineer has been developing EHR software since 2001 and at the time of the interview was graduating as a medical doctor.

Interviewees thought that the AAIR-based ranking seems “very reasonable” (rankings based on other criteria were not shown) and that standards should be enforced. After MEE-based PIRs were briefly explained to them, participants thought PIRs could ease acceptance of EHRs; the CEO stated that metaphor-based EHR design is “a good way forward”; and, the physician engineer recommended to “avoid metaphors that stray away from familiar characteristics and vocabulary of paper records, prescription forms, protocols, and workflows in use”. This last comment reinforces context-based metaphors, in line with the work of Bowers et al.⁽¹⁰⁾

DISCUSSION

Our findings indicate that perceived usefulness and ease of use are important to users, supporting the work of Yunus and Mohammad⁽¹²⁾. However, it is suggested that ease of use has more importance than perceived usefulness. Initially, functional requirements have smaller importance since they are expected “by default” in any version. However, the initial version (v1) of an EHR should focus on basic, essential, easily usable practice-supporting functions preferably; more sophisticated functions could be added in later versions. Notice that paper records *per se* offer no functions; minimal support to practice is provided by the look of an imprinted form at the most – i.e., their “interface” - thus highlighting the importance of CEU. “Initial minimalism” might be preferred since EHR standard users might have to adhere to it. Thus, it is important to present a clearly defined and accepted set of technical functions and features to support medical practice, legal impositions, and interoperability goals⁽¹⁶⁾. In this scenario, users should not be able to easily change the set, since EHRs should support the set by default. Instead, users could have more leeway in specifying ease of use features in order to reduce barriers to a new EHR’s interface. As the EHR usage becomes natural, later versions could focus on efficiency (PER) and on new functions (FUR), as EHR experience is a predictor for usefulness (i.e., functionality)⁽¹⁷⁾. PIRs’ role would fade with time as in any software (e.g., the PER, FUR outliers in Figure 4 come from older, more experienced users).

In software engineering, ease of use is often achieved

by designing an app interface around metaphors. A magnifying glass to zoom in; a trash bin to delete items; a “meds cabinet with lock and key” in an EHR for security awareness are examples of such metaphors. These metaphors are MEE-motivated and as such, could help on eliciting and implementing PIRs. Since PIRs permeate most EHR requirements classes, as do quality characteristics in ISO 25010, software engineers would benefit to elicit EHR requirements using metaphor-supported techniques that are familiar to practitioners.

Some PIRs might be apparent to healthcare professionals, but difficult to verbalise to software engineers. Consequently, observing how doctors and nurses perform their routine work could facilitate the collection of necessary information to specify metaphors, including the use conversational techniques to validate them.

In our research study, impressions were collected from thirty EHR healthcare practitioners and four EHR stakeholders in Brazil. Since this number can be deemed small, the collected evidence is statistically limited. Also, the respondents’ impressions and projections of benefits might reflect cultural and contextual aspects. Another threat to validity is the strong subjective component embedded in the respondents’ judgement. As such, the validation experiment can be considered to have produced “face validity”⁽¹⁸⁾. Subjectivity was reduced by using expert EHR users and developers as validators, making their projections realistic⁽¹⁸⁾; EHR developers should also look at replicating our ranking experiment with their clients to properly steer their decisions considering the reality of their target-context.

Albeit its limitations, the evidence collected in this paper offers support to decision making in EHR software development and its evolution (e.g., which requirements to implement in which EHR software version).

CONCLUSION AND FUTURE WORK

In this paper, it was found that Security (SEC) and Comfort & Ease of Use (CEU) PIR classes are the two most important classes for adoption of EHRs and that Functional Requirements (FUR) are less important in early EHR versions. Implementations of SEC and CEU include high concentrations of PIRs, it is thus, plausible to conclude that PIRs can be deemed important for EHR adoption and should receive top priority in EHR development and evolution. Yet, PIRs’ importance fades as versions evolve.

As the world population ages, EHRs can offer a way to mine information, support and safeguard diagnostics about a growing patient base. SEC and CEU implementations are likely to use techniques such as Blockchain and Artificial Intelligence. Also, as the 2020 world’s pandemic pushes medical practice towards telehealth, longitudinal studies could be undertaken through our approach to explore PIRs’ coadjutant role to improve practice behaviour and EHR software engineering.

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