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Improving meaningful use and user experience of healthcare information systems towards better clinical outcomes

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Abstract

This paper outlines a practical approach for enabling user-centric healthcare information systems development in large scale. The approach is especially powerful at the current stage of clinical informatics adoption by the leading countries which have already set deadlines for standardized capture and sharing of personal health records at national level. This stage is followed by more efficient usage of the data and improvements in clinical processes as topical action points towards optimizing actual clinical outcomes. So far the program for meaningful use in the US and strong orientation of the Nordic countries have led to reasonable availability of electronic health records, but challenges remain in their actual utilization for clinical use and readiness for new clinical processes. We propose an innovative and scalable approach for supporting the systems development, which empowers the users not only to solve problems of use, but to contribute excellence in clinical behaviour with the experiences and insights along the actual work. As a result, conceptual framework is presented and a couple of examples presented how user experience monitoring support to improve measurement of data accessibility, system use and clinical behaviour towards better clinical outcomes.

Keywords: information systems, hospital information systems, usability, usability testing, benchmarking, public procurement

Tiivistelmä

Tässä artikkelissa hahmotellaan käytännöllinen lähestymistapa terveydenhuollon tietojärjestelmien käyttäjäkeskeisen kehityksen mahdollistamiseksi suuressa mittakaavassa. Tämä lähestymistapa on erityisen tehokas nykyisessä sähköisten potilastietojärjestelmien käyttöönoton vaiheessa kun edelläkävijämaat ovat jo tavoiteaikataulunsa yhtenäisen potilastietoaineiston taltioinnille ja jakamiselle kansallisella tasolla. Tätä vaihetta seuraa parempi tiedon hyödyntäminen ja parannukset kliinisen työn prosesseihin, joilla päästään kohti parempaa hoidon vaikuttavuutta. Tähän mennessä ns. meaninful use -kannustinohjelma Yhdysvalloissa ja Pohjoismaiden päämäärätietoinen kehitys ovat johtaneet tarkoituksenmukaiseen potilastietojen saatavuuteen, mutta haasteet ovat niiden kunnollisessa hyödyntämisessä kliinisen käyttöön ja uusien työtapojen mahdollistamisessa. Ehdotamme innovatiivista ja skaalautuvaa tapaa järjestelmäkehityksen tueksi, jossa käyttäjien avulla ei pelkästään korjata esiintyviä ongelmia vaan edistetään kliinisen käyttäytymisen erinomaisuutta oikeasta työstä saatavilla kokemuksilla ja näkemyksillä. Tuloksena esitellään käsitteellinen malli ja kaksi esimerkkiä, miten käyttäjäkokemuksen seuranta tukee tiedon käsiteltävyyden, järjestelmien käytön ja kliinisen käyttäytymisen mittaamista kohti parempaa hoidon vaikuttavuutta.

Avainsanat: tietojärjestelmät, sairaalan tietojärjestelmät, käytettävyys, käytettävyystestaus, vertailukehittäminen, julkinen hankinta

Introduction

In order to improve outcomes of healthcare services, there has been strong orientation towards more digitized workflows of healthcare professionals. Many countries are already on the way of utilizing countrywide standards for capturing and sharing personal health records. While adoption rates of electronic health record (EHR) systems are getting reasonable, the challenges remain for practical ways to improve clinical processes and health outcomes.

Many electronic health records have poor usability, leading to user frustration and safety risks. Usability is the extent to which the technology helps the users achieve their goals in a satisfying, effective, and efficient manner within the constraints and complexities of their work environment. [1] For example, in the US "meaningful use" program places emphasis on the adoption of certified EHR technology and more specifically describes the quality EHR use must take, but meaningful use has missed the mark in defining EHR usability from the end-user's perspective according to Nancy Fabozzi. [2]

Adoption of electronic health records have reached 95-100 percentage in the Nordic countries which are mentioned as a global leaders in the use of EHR systems [3]. National eHealth policies call for improved quality, effectiveness and patient empowerment consistently across the Nordics. Slight differences can be found between the countries, for example Sweden and Denmark emphasize improved usability, while Finland is more emphasizing improved IT architecture. [4]

From an international perspective, meaningful use is seen helpful for a country's health care system if emphasis is placed on making the technology functional and valuable. Economic incentives have also been used in conjunction with regulation to facilitate interoperability, but IT systems may become attractive because of the benefits they provide to the user organizations, not because of external incentives. Both government and private organizations have seen playing important roles in the development of meaningful use, while it is suggested that responsibility of infrastructure for standardization and interoperability would be taken by a dedicated organization – whether governmental, private or non-profit. [5,6]

In Finland, there are common standards and dedicated services in place for nationwide patient data repository called Kanta. For operational EHR system implementations there are going to be different approaches within the country (i.e. Apotti programme procuring a commercial EHR product, UNA defining specifications for EHR procurement and ASTE providing an open source alternative for a modular EHR). This makes a good starting point to further develop the systems in terms of more efficient use and better end-user experience for the following reasons:

- Competing approaches encourage software vendors together with end-user organizations to improve operational quality in comparison with the others, not just pretending to be the best number one solution without any national benchmark.

- Economies of scale are already there when there are regions with more than million citizens for the major implementations (e.g. Apotti).

Topical initiatives for EHR system procurements set data interoperability as a prerequisite and emphasize utility and usability as important measures of quality. Figure 1 shows how systems can be evaluated as the system maturity evolves and how this is related to the stages of meaningful use programme established in the US.

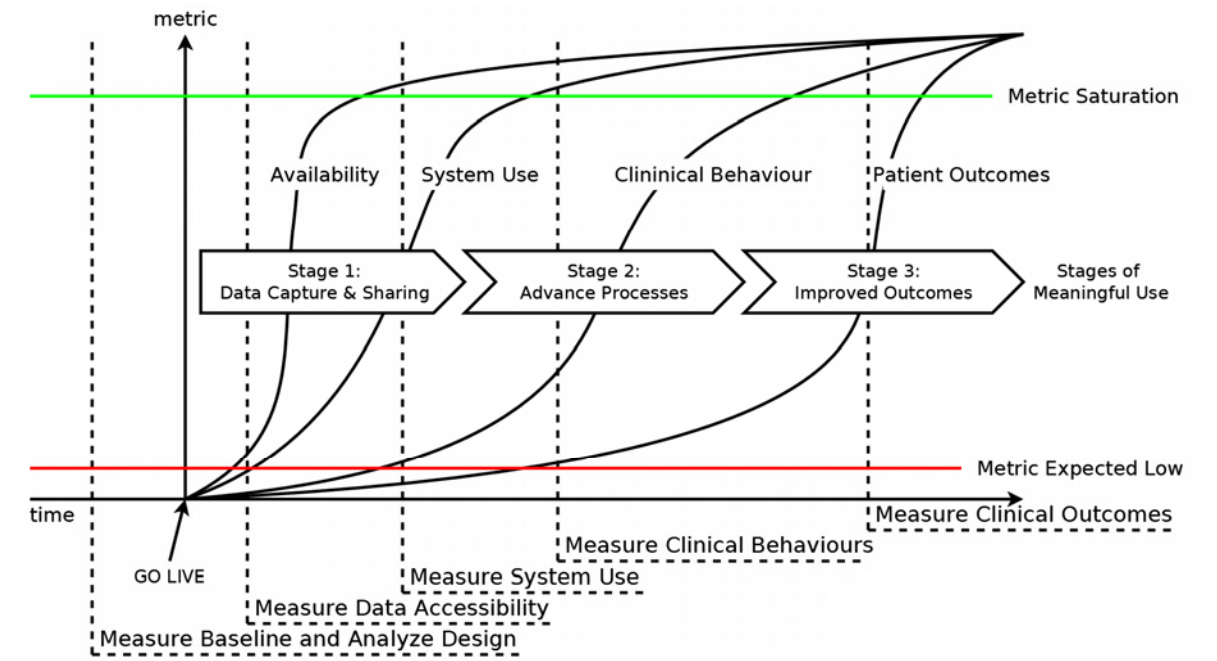

Figure 1. Evaluaton framework for measurement of Health Information Systems at different phases of maturity [7] and Stages of Meaningful use [8]. Each metric is expected to indicate strong increase followed by its saturation in the presented order when overall system maturity develops.

Availability can be measured with patient data capture and sharing possibilities (MU Stage 1). System use can be measured with the system usability for desired tasks (predefined clinical processes). Clinical behaviour can be measured with the observation of actual clinical behaviour and its development (MU Stage 2: advance processes). Patient outcomes can be measured with health benefits experienced by individual patients and impact on population health (MU Stage 3: Improved outcomes).

Scope of research

Based on the evaluation framework, the following research questions formulate the scope of this paper and will be addressed through a couple of examples concerning information systems for clinical use.

1. Can clinical behaviour be observed for a certain workflow?
2. Is every aspect of an expected clinical process evident in reality? If not, why?
3. Can clinical behaviour be improved based on the observations?
   - By modifying the system
   - Based on negative/positive experiences on the system use
4. Is the proposed construction economically feasible and practically scalable for the initiatives in large health information systems?

Hypothesis and proposed construction

Changing the system under development is expected to lead in improvements on system utility and usability (i.e. suitability and quality of use for predefined tasks) and advances on clinical processes (i.e. better performing processes by means of redefined tasks). Utility can be estimated by coverage of system capabilities for different domain areas and involved tasks of healthcare information system, such as making appointments, prescribing medication, radiology imaging, checking information on patient portal etc. By definition, utility of the system to be used for certain purpose necessitates that there is an advantage of using (compared to

not using) it and thus it is needed to have a reasonable level of patient data availability (Figure 1) before addressing system use and its usability. In system procurement it is possible to compare existing products on the market by assessing their utility. Utility related features form the obligatory requirements for system adoption while usability related measures can be used for comparing their predicted value in operational use.

Gathering user experiences: User experience can be seen as user's subjective perception of user interaction and other contextual factors. For understanding user interaction with the system, it is further divided into user inputs and the system outputs. These can be captured in an objective manner for further analysis of user interaction as is. For gathering the subjective perceptions, the user is enabled to provide any positive or negative indications of their spontaneous feelings regarding the system use while working.

Analytical evaluation

Observation of clinical behaviour requires actual follow up of work related tasks and information processing related to clinical decision making. To make it possible, it must be feasible to observe and gather the information about clinical behaviour in a way which is also acceptable concerning patient safety and privacy. We have experimented a procedure for user experience monitoring in different working environments for few years. The procedure applies an apparatus to capture user interaction at workstation computer combined with optional camera and microphone recording to capture the working context. In addition to the objective recordings, the procedure involve user initiated triggering of any moments during work which might be useful to be analysed afterwards.

Making a clinical process evident means that the observations are utilized to understand how expected processes exist in the real world. Formally documented processes often involve details which don't even exist in reality, or the workflow involve shortcuts or additional work which are not visible to those persons who design and try to improve the processes. First step to make any clinical process evident is to find objective evidence about occurrence of an expected clinical workflow from start to finish, or at least each task and decision making situation of the process happening somewhere in practice. This requires an unobtrusive way for making the observation in a realistic context, not asking someone to show or pretend that certain task is possible to execute just in an artificial situation.

	Meaningful use: Stage 1		Stage 2	Stage 3
Measure	Availability	Use	Behaviour	Outcomes
Means of improvement	Patient data capture, access and exchange	Task performance and process automation	Clinical decision support, collection of evidence and new processes	Preventive care, patient engagement and new services
Objective	Standardization	Problem elimination	Search for excellence	Impact driven interventions

Table 1. Importance of different means and objectives of improvement is depending on which measure is providing a steep curve of development along different stages of meaningful use. E.g. improving system use by eliminating usability problems is starting to pay off when high system and data availability is already widespread through standardization.

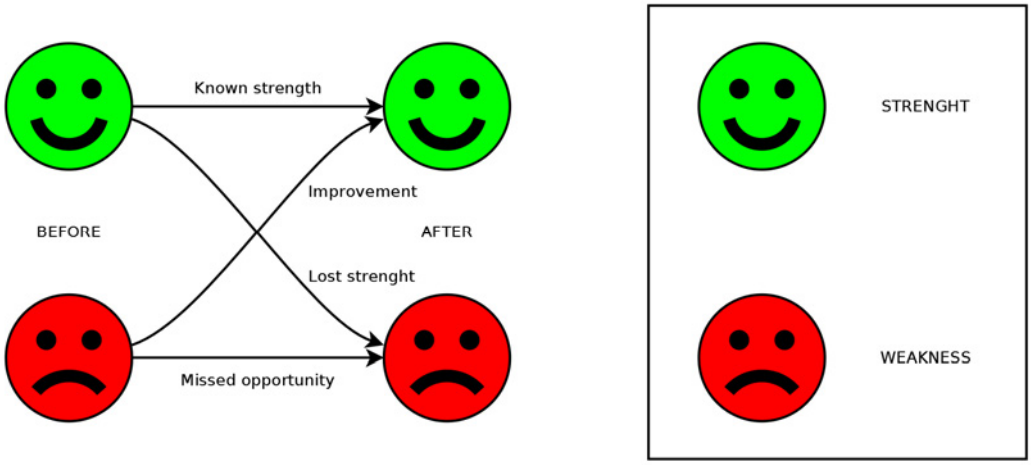

Figure 2. Development of positive and negative aspects of system use before and after system change or an extended period of use between the times of observation.

Concentrating on improvements and avoidance of lost strengths can be done by observing clinical work at least for reasonable period at two different time point – before and after system change or development, or just to follow the learning curve of the system use and organizational behaviour. This enables a formative development approach to make improvements on identified weaknesses and to preserve the known strengths. Let's assume that we gather negative and positive experiences of use at certain system and organizational context as presented in figure 2 with symbols of happy and sad faces. If any observed positive or negative experience repeat itself in quantities or can be seen as very significant qualitatively, it qualifies as a strength in the positive case and a weakness in a negative case.

Examples

Case 1: Scenario based usability testing has been applied in a large scale patient health record (PHR) system project for comparison of two alternative system from different vendors for procurement decision making. These vendors had already passed preliminary evaluation for their capabilities to deliver the requested system as well as their product proposal to meet obligatory requirements for desired utility. Testing scenario was based for chosen domain areas and each scenario was composed of predefined tasks in amounts from eleven to nineteen. Although the actual use couldn't be measured for the prospective systems, suitable usability testing arrangement was used for predicting their usability as realistically as possible.

1. Clinical behaviour couldn't be observed in this case, but test scenarios gave a good reference to compare the systems usability for desired workflows and to-be clinical behaviour.

2. Suitability for desired clinical processes were partially evident so that, on average, 46,67 % of the test tasks were completed with system A and 74,81 % with system B in a reasonable time.

3. Clinical behaviour cannot be reasonably improved by modifying the system when system use is expected to be below 75 %. System usability and training remains the priority until the system use is expected to reach 90 %. Most likely the system usability can be improved by developing the system based on usability testing results, since there are still more than 25 % of the needs unmet for system use even when considering the better performing system B.

4. The testing construction and arrangement enabled the project office to conduct 50 testing sessions by two usability specialists as test moderators. Two office room were equipped with portable and non-intrusive user experience monitoring equipment for conducting parallel sessions to meet a given schedule engaging 80 test users in total. Traceable comparison test results were obtained without a need to go through all the recordings afterwards and with below minimum recommended tester resources (one person instead of two recommended by Lowry, S. et al. [1]), while all the data logging responsibilities were fulfilled or exceeded (e.g. duplicated recording of moderator's log).

	System A		System B	
Efficiency	46,67 %	6,60	74,81 %	9,90
Errorlessness	10	7,33	12	8,80
Satisfaction*	8	1,76	13	2,86
Usability*	Score for A	15,69	Score for B	21,76

Table 2. Usability comparison of two PHR systems in clinicians' use based on moderated usability testing. Task completion rate (efficiency), errorlessness and user satisfaction are measured and quantified as described in the Apotti documentation [8]. (*) Satisfaction and usability scoring here is based on testing only; entire comparison involved complementary measures and other domain areas in addition to clinical ones resulting in overall usability scores of 59,66 vs. 71,20.

Case 2: User experience monitoring is applied when a speech recognition system is considered for replacing most of clinical dictation and transcription writing in several wards at a university hospital. Speech recognition systems have been common in radiology, where vocabulary is well established and transcription structures are rather straightforward. Elsewhere, transcription services utilizing semi-automatic speech recognition are widely used to replace transcription work, but it doesn't really change or improve the existing workflow as every transcription needs to be reviewed afterwards by the person who dictated it. Implementation of new speech recognition system would change the clinical process, since it makes the separate transcription task unnecessary and produces reasonably structured patient journal entry straight from each dictation.

1. Clinical behaviour can be observed in this case before and after the new system implementation, since both workflows are mainly carried out at the computer workstations by involved healthcare professionals.
2. Certain aspects of clinical processes differ between three different specialized care units, although workflows have been always completed in a way or another. For example, some physicians used to write patient journal entries by themselves, instead of dictating them for transcription.
3. Clinical behaviour can be reasonably improved by changing the system, provided that the new system can reach previous system's level of data accessibility and accomplish reasonable system usability. System usability and clinical process can be further developed based on user experience monitoring.
4. Proposed construction for user experience monitoring enabled more than 10 users to be involved in work study for 2 days duration each while doing their daily work as usual. Arrangement of the study required approximately 10 on site visits during three weeks of monitoring.

	Process I (before)	Process II (after)
Workflow complexity	Computer assisted dictation and transcription workflow	Speech recognition system and taxonomy maintenance, no transcription needed
Deviances	Outsourced transcription service for balancing workload	To be found out
User experience	Ok for physicians, extra workload for secretary	To be monitored
Clinical impact	5000 operations a year, of which ~50 % unnecessary	Target 6000 operations a year, of which <20 % unnecessary

Table 3. Process development by means of decreasing workflow complexity and improving decision support can improve clinical impact. Deviances from expected workflow and clinicians experience on system use is followed to assure the quality and to develop the process feasibility for better clinical impact.

Empowering user contribution and innovation in large scale

Practical strengths and weaknesses of a clinical work related system can be evaluated with scenario based usability testing as conducted in case 1, provided that the system capabilities and information exchange policies are already reached maturity as a high availability of patient data. Further contribution for systems development can be employed by healthcare professionals doing their work in simulated or actual environment, and monitoring it without disturbing their flow of work too much. This makes user contribution more efficient in two ways: observations in real work reveals actual problems of use, and wasted working time is kept to minimum.

Improvements in workflows are not only about avoidance of problems, but also positively innovative clinical behaviour can be learned from the professionals who have ended up using their own ways for searching excellence. Many high performers also know what the tricks are for streamlining the workflow and improving co-operation with colleagues. Collecting this information provides opportunities to share the best practices for training purposes and not only pushing the change by means of information system redesign.

Discussion and conclusions

This paper elaborated an approach for user experience monitoring which can be applied for comparison and development of Health Information Systems. Effective contribution of the approach requires that accessibility of patient data is not the issue anymore, but usability issues remain a bottleneck of meaningful system use. For further research, a positive deviance paradigm would provide new approaches to contribute process improvements and clinical behaviour instead of just eliminating problems. It's about searching for exceptional performance of people and their ability to succeed through different or deviant behaviours while facing the same resource constraints as others [10, 11].

The couple of presented case examples make it evident that the proposed approach and construction fulfil two important requirements in healthcare settings: Firstly, the results follow the strict objectivity of EU procurement rules and were contributing a decision making of choosing a vendor for Health Information System for more than 300 M€ investment in case 1. Secondly, the procedures of handling recordings which often carry highly confidential patient information are secure and approved by a hospital district in case 2.

Both cases indicate that the proposed construction for user experience monitoring is suitable for the purpose

and less laborious than manual observation, while generating more objective evidence. On the other hand, the applied technology was supported by original developers of the monitoring technology to manage any operational issues during the case studies. For large scale utilization of user experience driven development of Healthcare Information Systems, we suggest further efforts to evaluate and develop improved functionality, better operational reliability and sufficient organizational roles for enabling the proposed approach.

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