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Evaluation of user acceptance of data management systems in hospitals - feasibility and usability -

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1. Abstract

The use of modern information technology (IT) offers tremendous opportunities such as reducing clinical errors and supporting health care professionals in providing care. However, there are also hazards associated with IT in health care. Many researchers report problems during evaluation in a health care environment. This paper will discuss whether evaluation of information systems in health care is really different from IT evaluation in other surroundings and, with an example, will show that the effort for such can be relatively low, while large benefits for decision makers can be realized.

2. Keywords

Evaluation, health care information systems, study design, questionnaire, user acceptance, discharge report.

3. Introduction

Information technology (IT) is emerging more and more in health care. For example, decision support systems are introduced to support decision making, knowledge servers allow direct access to state-of-the-art clinical knowledge, and health care professional workstations offer a vast amount of functionality (such as order entry, workflow management, report writing) in order to support health care professionals in inpatient and outpatient units.
It is evident that the use of modern information technology offers tremendous opportunities, but there are also hazards associated with information technology in health care: modern information systems are costly (e.g. (Anderson, J 1999), (Enning, J, Bakker, A 1995), (van Gennip, E, Bakker, A 1995)), their failures may cause negative effects on patients and staff (Beynon-Davies, P, Lloyd-Williams, M 1999), and possibly, when insufficiently designed, they may result in spending more time with the computer than with the patient ((Hendrickson, G, Kovner, CT 1990)).
Therefore, a rigorous evaluation of IT in health care is recommended and of great importance for decision makers and users of future information systems (e.g. (Rigby, M 2001), (Wyatt, C 1997)). Evaluation can be defined as the decisive assessment of defined objects, based on a set of criteria, in order to solve a given problem (Heinrich, L 1999). Moreover, monitoring and evaluation of clinical software may become a must in the future, when recommendations become regulations backed by the FDA (United States Food and Drug Administration) or other national legal bodies, and software programs are considered to be medical devices (Miller, R, Gardner, R 1997).
Objects which may need evaluation are hard- and software components, processes and services, and also the persons involved and their interactions with technical components. This comprehensive view is based on the following definition: an information system is comprised of all of the information processing in an organization, as well as the involved human and technical players in their information processing roles (Winter, A, Ammenwerth, E et al. 2001). In this paper we consequently consider information systems as a whole as evaluation objects, and information technology as a tool which is part of the overall information system.
Many different questions can lead the evaluation of information systems and their information technology. Typical evaluation questions are, for example:

- Which information technology should be selected and installed?
- What is the usability of the information technology?

- What are the technical and system features (e.g. performance, software quality) of the information technology that affect its use?
- Do the users accept the information technology and use it as intended?
- How does the information system affect structural or process quality (time saving, data quality, clinical workflow, patient administration) with regard to different users (physicians, nurses, administrative staff)? Does it work effectively? Does it reach its goals?
- What are effects of an information system on the quality of care?
- Are the patients satisfied with the information system?
- What are the investment and operational costs of information technology?

Despite a large amount of published evaluation studies (e.g. van der Loo found over 1500 citations on evaluation of healthcare information systems between 1967 and 1995 (van der Loo, R 1995)), many authors report problems during evaluation. For example, the following problems are frequently mentioned:

- Unclear evaluation goals or changing evaluation goals during the study
- Large efforts needed for the preparation and execution of the study
- Insufficient availability of valid evaluation instruments (such as questionnaires)
- Complex and partly contradictory results
- Dependence of the results on the motivation and expectations of the users
- Uncertainty whether results can be generalized to other environments or information systems
- Dependence of results on organizational issues

Several authors state that evaluators of IT in health care can learn from clinical trials (e.g. (Tierney, W, Overhage, J et al. 1994)) and from the systematic study designs which are standard for all major clinical trials in health care. Strong recommendations for the design, execution and publication of studies, and even meta-analysis studies, exist (e.g. (ICH-GCP 1995), (Johnston, M, Langton, K et al. 1994), (Schäfer, H, Berger, J et al. 1999)).
However, some experts are also of the opinion that there are inherent problems in information system evaluation which do not allow the simple transfer of study designs and recommendations from clinical trials to information system evaluation studies ((Heathfield, H, Pitty, D et al. 1998), (Miller R, Gardner R 1997)). Traditional clinical trials strive to objectively measure effects of a diagnostic or therapeutic intervention on an individual patient, while information system evaluation studies attempt to measure effects of a new technology on structure, processes and outcomes of patient care ((Donabedian, A 1988), (Shea, S, Sideli, R et al. 1995), (van der Loo R 1995)). The question of whether problems in the evaluation of information systems in health care are due to methodological insufficiencies, or rather due to more complicated circumstances than in clinical trials still seems to be unanswered.
Our hypothesis is that the problems associated with the evaluation of IT in health care are caused by special conditions. In demonstrating this we will focus on three main problem areas: the complexity of information systems, the complexity of the evaluation environment, and problems with regard to the availability of participants. In this paper, we will also discuss and present the design and execution of a study of a medical data management system at the Innsbruck University Medical Center. This example will show that the effort for such studies, if well prepared, is relatively low, while large benefits for decision makers can be realized.

4. Problem areas in the Evaluation of Information Systems in Health Care

As mentioned above, difficulties often arise when information systems are evaluated in health care. Various complexities lead to barriers which hinder meaningful and useful evaluation. Three of these major complexities and barriers are briefly described below.

4.1 First problem area: Complexity of the evaluation object

Evaluations of IT in health care deal with information systems. The definition given in the introduction highlights that it is not only the information technology (i.e. hardware and software) which has to be evaluated, but the information processing, and the interaction of the information technology with its environment. (Miller R, Gardner R 1997) stated that the information environment of a typical institution, comprised of e.g. the cooperation between laboratory, admissions, pharmacy and dietary departments results in an increasing number of installed products with different configurations. In fact, the success of information systems heavily depends on the ways they are used ((Forsythe, DE, Buchanan, BG 1992), (van Gennip E, Bakker A 1995)). It depends, e.g., on its matching with clinical workflow, on the organization of its introduction, on training and support, on the use of offered functionality, and especially on the motivation of the users. All of those aspects together make up the situation which has to be evaluated.

4.2 Second problem area: Complexity of the evaluation environment

Evaluation of information systems usually takes place in a complex environment. This environment often includes different professional groups (such as physicians, nurses, patients, administration, IT staff, hospital management, funding bodies), its complex co-operative working and decision making processes, and its high dependence from external influences such as legislation, economic constraints, or patient clientele. This makes the clinical situation (and therefore the information system which is to be evaluated) quite unstable and volatile.

Furthermore, different stakeholders often have different conceptions and views of a successful information system (Heathfield, H, Hudson, P et al. 1999). For example, the clinical user may want a well-designed, easy-to-use, supporting system, the administration may want a cheap system, while the IT staff may want a system which is easy to customize and to support. There may thus be a multitude of evaluation goals, the success criteria are complex, and the ideas of the different groups may even been conflicting. The multitude of possible objectives and questions makes a systematic evaluation study quite difficult ((Heathfield, H, Peel, V et al. 1997), (Jorgensen, T 1995)).

4.3 Third problem area: Availability of participants

For a systematic evaluation study, a sufficient number of evaluation objects (such as staff members, wards, patient records) are usually necessary. The problem is often that it is hard to find enough motivated participants to join a study.

The reasons for not wanting to participate are diverse. Participating in a study usually requires a lot of effort from the involved staff (e.g. learning a new application system, filling out questionnaires, being involved in time measurements) (Wyatt, J, Spiegelhalter, D 1992). In addition, the benefit of joining a study is usually not obvious (the study is conducted in order to investigate possible effects). Participation may even include some risks for the

involved staff. For example, data may be lost when a new data management system fails, which may enforce redundant data recording. Such efforts and risks are usually not paid for by the organizers of studies. As opposed to clinical trials, there is usually no financial compensation for the participants. And, finally, there may be a reluctance to participate in evaluation studies from the side of the hospital's management due to diverse reasons such as fear of negative outcome.
Also, technical limitations may restrict the broader introduction of a new information system. For example, the introduction of a new nursing data management system on wards requires sufficient technical equipment, interfaces to existing systems, and staff for training and support. Often, there may not be enough resources to provide such resources to a greater number of wards.
Another problem makes the situation even worse: Many study designs need a unit (e.g. a ward) as an evaluation object. For example, when evaluating a new nursing data management system, nursing workflow may not allow that some nurses on one ward work with the system while others don't (e.g. this may split the patient record into two parts). Therefore, each ward becomes an evaluation object. For these kind of studies, it is significantly more difficult to recruit a sufficient number of evaluation objects.

4.4 Recap

Evaluation studies in health care IT take a lot of time, resources, and know-how. Some problems can be reduced by following some general guidelines, and by learning from other areas such as clinical trials. However, there seem to be aspects which are different in IT evaluation when compared to other areas. Such differences include the complexity of the evaluation object, the complexity of the evaluation environment with its multitude of possible evaluation views and questions, and the limited availability of participants.
Research in the area of health care IT evaluation is just beginning. It is mostly unclear what 'good' information systems look like. Clearly defined methodological guidelines which take the peculiarities in health care into account are still missing. It would be very helpful to have a guideline for IT evaluation studies in health care. Hence there is still a lot for researchers to do.
With this in mind, an evaluation was conducted on user acceptance of the electronic physician discharge report writing system at the Innsbruck University Medical Center. This study demonstrates that actually, if well prepared, decision makers can realize large benefits from an evaluation study with relatively little effort.

5. An example: Evaluation of user acceptance of an electronic physician discharge report writing system at the Innsbruck University Medical Center

5.1 Goal of the Study

The goal of the study was to evaluate the positive and negative effects of the process of the electronic physician discharge report writing system at the Innsbruck University Medical Center (based on Cerner HNA Millenium®) from the view of users on three wards: neurology, internal medicine and surgical transplantation. The study was a prospective, descriptive, quantitative study.

The functionality of this system comprised creating, correcting/editing and retrieving discharge reports. Three user groups were selected for this study: junior physicians, senior physicians, and clerical assistants. Each occupational group carries out various different tasks related to discharge report writing.

5.2 Study Design

Through a cross-sectional study design, a representative sample of users were questioned via a written, standardized, validated questionnaire based on (Boy, O, Ohmann, C et al. 2000). The distribution and return of questionnaires was done through the internal mail system of the Innsbruck University Medical Center. Completeness was guaranteed through directed follow-up with subjects.
The survey was carried out in February 2002 and the sample size was obtained from the users known in the system. All secretaries and approximately randomly selected 20-30 physicians per clinic were questioned. No distinction was made between ambulatory and in-patient areas.
For each user who was questioned, the number of finding/discharge reports which were drawn up in the last 3 months were determined on hand of the available data. This should provide an indication of the validity of the sample.

5.3 Execution

The execution of the study followed various steps. These steps are described in greater detail in the following:

5.3.1 Literature search

An in depth literature search was conducted in order to see if questionnaires of similar type as was needed already existed. The time invested in the literature search at the beginning of the study proved to be an effective method to reduce the overall amount of time needed for this type of study. Several questionnaires were discovered which closely met the needs of the study. The literature search also drew attention to the concept of validated questionnaires, which are of great importance when high reliability of a questionnaire is aimed for.

5.3.2 Project team meetings

Several meetings took place with the entire project team which consisted of two representative from the IT department and of the two researchers conducting the study. The project team first met to discuss how the study was to be carried out. Follow-up meetings took place to discuss such things as the study protocol, progression of the study, and organizational matters. Other forms of communication such as email, phone, and informal ad hoc discussions reduced the need for more meetings. It was found that overall only few gatherings of the entire project team were needed to conduct the study.

5.3.3 Write and review study protocol

A study protocol was drawn up upon completion of the first major project team meeting. The protocol included such items as who was to carry out the study, goals of the study, boundaries of the study, a study timeline, distribution of tasks, and information about the design and execution of the study. A clear study protocol helped to inform, and keep everyone informed about the study. This helped to reduce the overall time needed to complete the study.

5.3.4 Questionnaire design, validation and distribution

The next step was to design a suitable questionnaire for the task at hand. In order to do this, the results of the literature search were applied in order to devise a questionnaire which would extract the needed information from the participants of the study. We were able to reuse a validated questionnaire provided by (Boy, O, Ohmann, C et al. 2000). Special attention was paid to how questions were formulated. The questionnaire needed to be formulated such that people with various occupations could read and understand each question without hesitation. In order to achieve this, the questionnaire was tested on two members of the clinical community. Each question was read out loud and the respondents were asked to answer out loud and relay any uncertainties. This approach helped the project team to see how the questionnaire could still be improved before it was distributed to the entire sample population.
Once the questionnaire was completed and tested it was ready to be distributed. Each questionnaire was prepared with an informative document describing the study, a time limit for returning the questionnaire, and contact information in the case that there were still uncertainties. This package was then distributed to the sample population via an internal mail system. This distribution method was chosen as it was inexpensive, fairly reliable, and quick.

5.3.5 Distribution / return of questionnaires

The collection of the questionnaires was carried out approximately 2 weeks after they were distributed to the sample population. A self-addressed return envelope was attached to the questionnaire which was to be used, once again via the internal mail system, to return the questionnaires to the project team. The majority of the questionnaires were returned in this fashion, however, follow-up was also carried out in order to increase the return rate. The sample population was systematically contacted in order to assure that they had completed the questionnaire.

5.3.6 Data entry and analysis

Once the questionnaires were received, the data was entered into a statistical software program (SPSS 10.0). Several statistical tests, including Pearson correlation, Cronbach alpha, and tests displaying medians and standard deviations, were executed on the data. Some results of these tests can be seen in section 5.4 (Study results).

5.3.7 Evaluation of results and drawing conclusions

Once the statistical tests had been run, it was fairly simple to analyze the results. The project team met once again to discuss the outcomes of the various sections of the questionnaire and were able to draw conclusions. The results were fairly simple to evaluate due to the nature of the questionnaire. Standardization and validation early on in the study helped lead to clear conclusions in the end.

5.3.8 Writing report

Although the writing of a report following a study is typically seen as being fairly time intensive, it turned out to be a fairly simple task in the case of this study. Continuous documentation throughout the study proved to be helpful and useful in drawing up results and conclusions. Combined efforts from all members of the project team made the task less daunting and was therefore completed in a reasonable amount of time.

These steps all took the following amount of time:

1. Literature search	4 hours
2. Project team meetings	30 hours
3. Write and review study protocol	6 hours
4. Questionnaire design, validation and distribution	23.5 hours
5. Collection of questionnaires	14 hours
6. Data entry and analysis	12.5 hours
7. Evaluation of results and drawing conclusions	12 hours
8. Writing report	16 hours
Total hours needed for the study:	118 hours

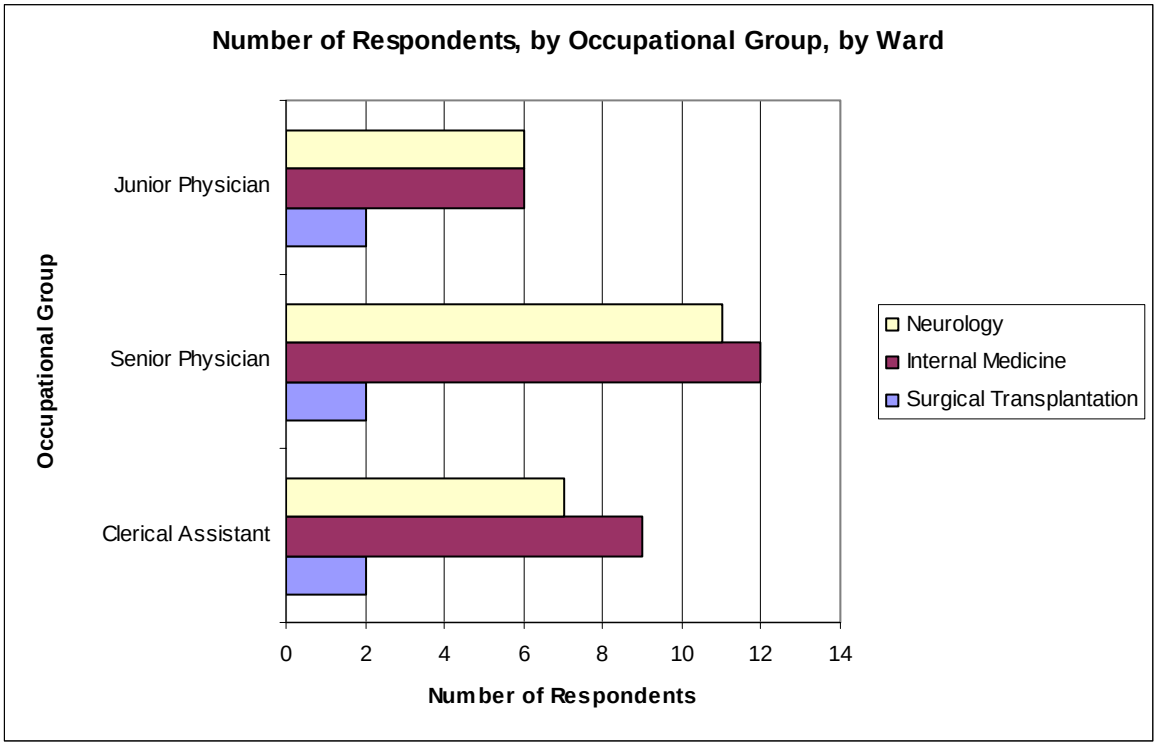
It can be seen that in total, only approx. 118 hours were needed to conduct a study which evaluated user acceptance of a new software application, across various occupational groups, and on various wards of a hospital.

5.4 Some Study Results

The outcome of the study proved to be very interesting, mainly due to the fact that results arose which weren't expected. This alone, from our point of view, made the study worthwhile and interesting. The following graphs display some of the results of the study with regard to the number of respondents to the questionnaire and mean values to satisfaction with the new computer-based tool.

5.4.1 Demographic Data

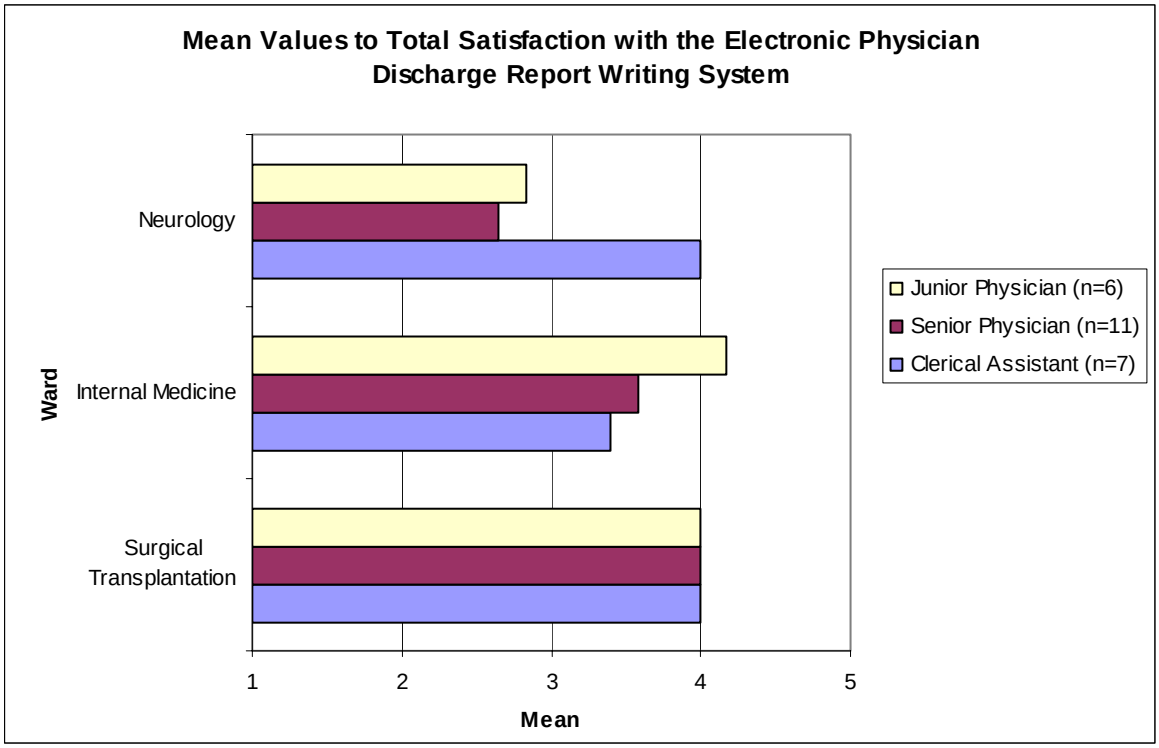
The following graph illustrates the number of respondents who answered and returned the study questionnaire. At a first glance it may seem that there weren't many respondents on the surgical transplantation ward. However, the sample size on this ward was fairly small due to the few employees who actually work there. Altogether, 24 of 34 (71%) questionnaires were returned by employees of the neurological ward, 28 of 46 (61%) from those of internal medicine and 7 of 10 (70%) of those from surgical transplantation. The overall return was therefore 59 of 90 questionnaires, or 66%.



Graph 1: Number of questionnaire respondents by occupational group (junior physician, senior physician, clerical assistant) and by ward (neurology, internal medicine, surgical transplantation).

5.4.2 Mean Values to Satisfaction

Graphs 2 displays the mean values to general satisfaction (by ward, and by occupational group) with the physician discharge report writing application. It can be derived from this graph that clerical assistants are generally quite satisfied with the application, whereas there is quite some discrepancy amongst junior and senior physicians with regard to their levels of satisfaction.
Some unawaited results were discovered, especially on the neurological ward and in internal medicine. On the neurological ward, it was found that clerical assistants were much more satisfied with the application than junior physicians. This is the opposite in internal medicine, where junior physicians seem more satisfied than the other two occupational groups. This was surprising, as we had awaited that in all departments, the clerical assistants would be the group having the greatest benefit from the new application system. Now, we detected that different occupational groups profit from the system in different ways in the different departments. Thus, further analysis is needed to be conducted in the area of work processes and flows in the next months.



Graph 2: Mean values to total satisfaction on all wards, by occupational group, with various functions of physician report writing in the hospital information system.
Scale: 1 – very dissatisfied, 2 – fairly dissatisfied, 3 – neither satisfied, nor dissatisfied, 4 – fairly satisfied, 5 – very satisfied.

6. Discussion

Information technology is becoming an essential part of health care. It is therefore of extreme importance to evaluate health care information systems to provide decision makers with critical information and to optimize systems for current and future users. Objects which may need evaluation are hard- and software components, processes and services, and also the persons involved and their interactions with technical components. This evaluation process is often very difficult and standard methods can't always be implemented.

The methods which were used in our study to evaluate user acceptance of the electronic physician discharge report writing system at the Innsbruck University Medical Center proved to bring about useful and interesting results. These methods, above all, displayed that information systems in hospitals can be evaluated effectively, with minimal resources, especially with regard to time.

It was of great importance to outline tasks and timelines in the study protocol in detail. Every bit of additional time spent during the planning of the study minimized time efforts in the end. The use of a validated questionnaire also turned out to be key in the execution of this study. It was found to be a very useful tool to collect the data needed from study participants. It was of great importance to spend more time at the beginning of the study to design the questionnaire appropriately. This additional time spent at the beginning led to less time having to be spent during data analysis and during the interpretation of results.

The results of the study were quite easy to evaluate, as the collection of the data through the questionnaire was already designed with specific methods of analysis in mind.

The results were of importance, as they drew attention to which parts of the information system users were satisfied and dissatisfied with. The results were especially interesting because they showed outcomes which weren't expected by the project team.

7. Conclusion

Evaluation of IT in health care is often seen as a complex and difficult task which can consume large amounts of time and other resources. However, through the study of the evaluation of user acceptance of the electronic physician discharge report writing system at the Innsbruck University Medical Center we were able to show that if well prepared, decision makers can realize large benefits from an evaluation study with relatively little effort. This study also showed that such an evaluation of IT is of extreme importance, especially because unexpected results often arise. Such evaluation are essential to arrive at how health information systems can be optimized for current and future users.

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