Objectifying User Critique

A Means of Continuous Quality Assurance for Physician Discharge Letter Composition

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Summary
Objectives: The aim of this study is to objectify user critique rendering it usable for quality assurance. Based on formative and summative evaluation results we strive to promote software improvements; in our case, the physician discharge letter composition process at the Department of Dermatology, University Hospital Erlangen, Germany.
Methods: We developed a novel six-step approach to objectify user critique: 1) acquisition of user critique using subjectivist methods, 2) creation of a workflow model, 3) definition of hypothesis and indicators, 4) measuring of indicators, 5) analyzing results, 6) optimization of the system regarding both subjectivist and objectivist evaluation results. In particular, we derived indicators and workflows directly from user critique/narratives. The identified indicators were mapped onto workflow activities, creating a link between user critique and the evaluated system.
Results: Users criticized a new discharge letter system as "too slow" and "too labor-intensive" in comparison with the previously used system. In a stepwise approach we collected subjective user critique, derived a comprehensive process model including deviations and deduced a set of five indicators for objectivist evaluation: processing time, system-related waiting time, number of mouse clicks, number of keyboard inputs, and throughput time. About 3500 measurements have been performed to compare the workflow-steps of both systems, regarding 20 discharge letters.
Although the difference of the mean total processing time between both systems was statistically insignificant (2011.7 s vs. 1971.5 s; $p = 0.457$), we detected a significant difference in waiting times (101.8 s vs. 37.2 s; $p < 0.001$) and number of user interactions (77 vs. 69; $p < 0.001$) in favor of the old system, thus objectifying user critique.
Conclusions: Our six-step approach enables objectification of user critique, resulting in objective values for continuous quality assurance. To our knowledge no previous study in medical informatics mapped user critique onto workflow steps. Subjectivist analysis prompted us to use the indicator system-related waiting time for the objectivist study, which was rarely done before. We consider combining subjectivist and objectivist methods as a key point of our approach. Future work will concentrate on automated measurement of indicators.

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1. Introduction

Physician discharge letters continue to be today's most important medium to share information between hospital specialists and a patient's general practitioner [1–3]. Accordingly, the composition of discharge letters represents an essential business process for hospital-based healthcare providers. Through the optimization of clinical core processes, particularly by utilization of efficient information technology, significant cost savings can and should be achieved [4].

Due to its importance the physician discharge letter composition can be considered a base functionality of hospital information systems (HIS). In spite of the continuous development of HIS since the 1960s [5–7] and discharge letter systems [8], the comprehensive breakthrough didn't occur until recently.

One reason is that every implementation project has unique criteria and may encounter unanticipated obstacles [9–11], which must necessarily be avoided or overcome through change management [12]. Whereas obstacles are associated with every system modification, it is important to start from an objective well-founded information base for change management. Evaluation of HIS and its discharge letter function is the first step to create such a foundation [13–16].

Several studies have evaluated discharge letter processes and discharge letter systems. For example Archbold [17], van Walraven [18] and Lissauer [19] evaluated the creation of dictated versus computer-generated letters. Bolton [20] analyzed if the discharge letter reached the general practitioner at all. Moormann [21] measured electronic discharge letter transfer volume.

Callen [22], Walker [23], Roth-Isigkeit [24] and Spießl [3] analyzed the quality with regards to contents; Lieb [25] evaluated the throughput time; others, for example Paterson [26] and O'Leary [27], evaluated both aspects in the same study.

Medical informatics literature mentions potential sociotechnological problems [28–30] as well as "user acceptance" and "user satisfaction" of health systems in general [31] or in other fields of application [32, 33]. Only few, for example Ammenwerth [31, 34] and Engel [35], address the evaluation of user satisfaction regarding discharge letter systems in particular. Otherwise, the literature is largely silent on the issue of "objectification of user criticism". Therefore, we decided to evaluate the objectification of user critique systematically.

This paper's goal is to objectify user critique as a key element for quality assurance. Our example focuses on the physician discharge letter composition process at the Department of Dermatology, University Hospital Erlangen, Germany. At the time of the study two discharge letter systems, with the core applications Soarian Clinicals™ and Microsoft Word™, were used to compose final physician discharge letters. We solicited and obtained all system users' personal perceptions for both discharge letter systems. We analyzed the results to quantify and qualify substantive reasons for emerging user dissatisfaction. Since we were faced with vague critique which had to be made tangible and specific, we were seeking an approach which would objectify and quantify user critique as well as workflows; essentially linking them with each other. This approach was substantiated by means of an evaluation and comparison of both systems through the use of a set of indicators. As a practical outcome we extrapolated a method, which renders user critique viable for constructive discussion, system and process optimizations, workflow management and continuous quality assurance.

For a detailed analysis and objectification of user critique six steps were defined:

- Step 1: perform data acquisition using subjectivist methods and identify research questions for in-depth evaluation
- Step 2: create a model of the discharge letter composition process (based on step 1)
- Step 3: define a formal hypothesis and key indicators for an objectivist system analysis (based on steps 1 and 2)
- Step 4: perform the objectivistic system analysis and measure those indicators (based on step 3)
- Step 5: present an objective comparison of the existing and the newly deployed discharge letter system, by means of indicators (based on step 4)
- Step 6: identify optimization possibilities within the newly deployed discharge letter system (based on steps 1, 2 and 5)

2. Methods

2.1 Study Environment

The clinical workflow management system Soarian™ (Siemens Medical Solutions Health Services Corporation, Malvern, PA, USA) has been deployed at University Hospital Erlangen, Germany since 2001 [36]. In October 2006 University Hospital Erlangen's Department of Dermatology initiated a change in technology to improve time efficiency of the composition of physician discharge letters. The discharge letter module Soarian™ Clinical Letter replaced the Microsoft Word™ (Microsoft Corporation, Redmond, WA, USA) text processing program, which was utilized in this hospital for many years.

The Department of Dermatology's 2007 patient census was 2218 inpatients, 891 day clinic patients and 50,817 outpatients [37]. 2154 inpatient discharges have been documented in Soarian™, for each of which a discharge letter had to be written. At that time, the physician discharge letter composition process was defined through standard operating procedures, containing mandated procedural and substantive requirements; for example form, content and a due date of 14 days for completion of the discharge letters; however a process model did not exist.

During a six-month pilot phase of the live version of Soarian™, user critique of the new discharge letter system emerged. User critique focused on two issues: users objected that Soarian™ was "too slow" and "too labor-intensive". Hence the comprehensive evaluation study presented in this paper was initiated[a].

2.2 System Environment

The technical infrastructure consists of analog voice recorders, standard office computers and printers and two discharge letter systems described below:

2.2.1 Discharge Letter System Word

The discharge letter system Word™ (referenced as "Word" to improve readability) is used for creating outpatient final physician discharge letters and inpatient preliminary physician discharge notes. It consists of the text processing program Microsoft Word™ (Version 2003 SP2; Microsoft Corporation, Redmond, WA, USA), a web-based discharge letter reminder list, accessed through Microsoft Internet Explorer™, and a file server, accessed through Microsoft Windows Explorer™ (▶Fig. 1).

For each letter type a template is bound into each unique user profile. Available clinical findings, in the form of electronic data, must be copied into the letter manually. For spell checking, the Microsoft Word™ internal function is used with user-administrated dictionaries. The created letters are saved with a manually assembled filename, grouped by preliminary, current and archived letters, and stored in respective folders of the file system.

The web-based discharge letter list is used for administrative oversight of discharge letters and dictations; of particular value is a function which provides timely reminders of upcoming due discharge letters. The system is a proprietary development on behalf of the Department of Dermatology and is based on Apache 2.052,

[a] The complete study results and a comprehensive description of all workflows are available in [38].

PHP 5.04 and MYSQL 4.1.11. Required information regarding each patient's stay, such as the discharge date, is electronically transmitted from the patient data administration/billing system. Information about the dictation creation time, the letter creation date and the letter dispatch date is documented manually by clerical staff as part of the transcription process.

2.2.2 Discharge Letter System Soarian

The discharge letter system Soarian™ (referenced as "Soarian" to improve readability) is used for the composition of inpatient final physician discharge letters. Soarian's Clinical Letter module is integrated into the web-based electronic health record (EHR) Soarian Clinicals™ (Version 2.0 C5 301.92 HF5; Siemens Medical Solutions Health Services Corporation, Malvern, PA, USA), which was designed to be accessed through Microsoft Internet Explorer™.

Soarian's structured discharge letter is defined in a template which describes the content structure, the ordering, and the layout of the document. The content sections, which were adapted from Word's discharge letter template, include salutation, diagnoses, anamnesis, relevant findings and discharge summary. Each paragraph can be automatically preloaded with findings from the Soarian™ database.

▶Figure 2 shows the editor and the selection of findings in Soarian. The spell check add-on IESpell™ (Red Egg Software) supports the typist with web-based or local dictionaries. The final layout check and print formatting are done with Acrobat Reader™ (Adobe Systems Incorporated, San Jose, CA, USA).

Soarian's discharge letter is saved in the EHR database using the clinical document architecture (CDA) [39, 40]. Documentation of relevant timestamps is fully automated.

2.3 Analyses and Evaluation

In September 2007 an initial survey was conducted to analyze the spatial and personnel structure as well as the information systems and related infrastructure within the Department of Dermatology. This preparatory analysis was primarily done using the inventory method [41, 42]. It utilized existing documents, reports and procedural instructions, which were available through the Department's quality management handbook[b].

In order to objectify the users' critique, the physician discharge letter composition process (referenced as "discharge letter process" to improve readability) and the two deployed systems were critically reviewed using subjectivist and objectivist approaches[c] [41, 43], by following the defined six-step approach.

2.3.1 Step 1: Data Acquisition and Research Question

A user survey and a process analysis were conducted using subjectivist methods during October and November 2007 to acquire qualitative data about users' perceptions regarding the discharge letter process, and about the process itself. The system users participated [42] in this subjectivist analysis [41, 43] by means of tacit knowledge through experience and transactional knowledge [44]. We dismissed the likelihood of participation bias, since all users of both systems were involved; specifically six physicians from two wards and a pool of three typists.

As a subjectivist indicator, user acceptance and satisfaction are often measured [31, 34, 35, 45]. Nevertheless, an opinion survey in the form of a written questionnaire was not performed in the Department of Dermatology for two reasons; first, the available pool of nine staff members was too small for a reliable statistical sample; second, since no workflow model existed, the field of evaluation was unclear at the beginning of the study and according to Ammenwerth [46] the estimated "why-questions can better be answered using interactive methods such as interviews".

Using semi-structured interviews, hospital staff were queried face-to-face during scheduled appointments at their workplace (physician's office and writing office). A standardized question set was used for each

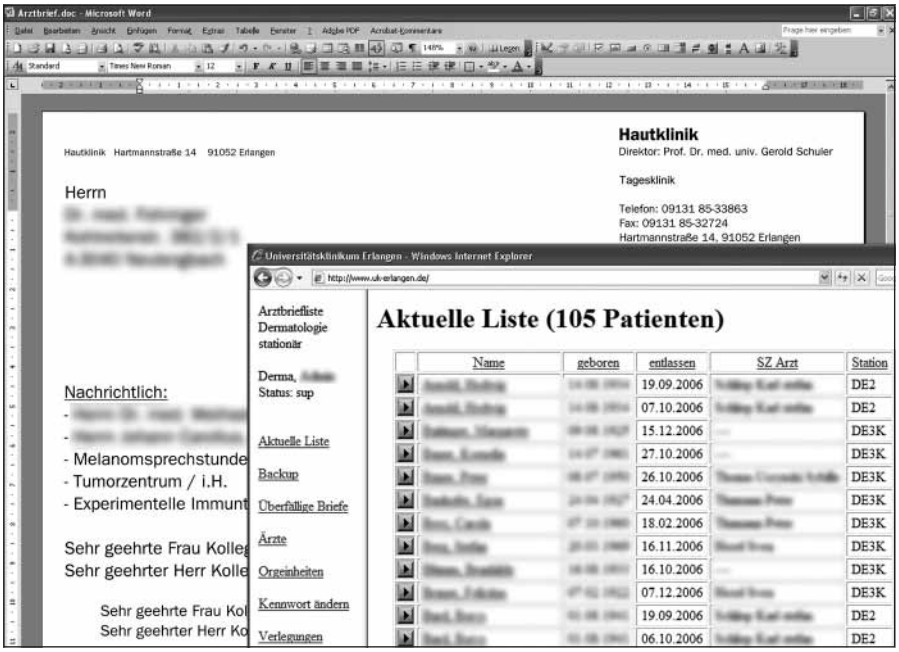

Fig. 1 Word-editor and web-based discharge letter reminder list. The standard application Word is used for creating, editing and printing the discharge letter. The web-based discharge letter list provides a status report of all post-discharge letters which have not been finalized, and creates reminders for physicians and clerical staff.

[b] The Department of Dermatology was certified according to ISO 9001:2000 effective June 12, 2002.

[c] "Note that these approaches are not entitled 'objective' and 'subjective', as those words carry strong and fundamentally misleading connotations" [43].

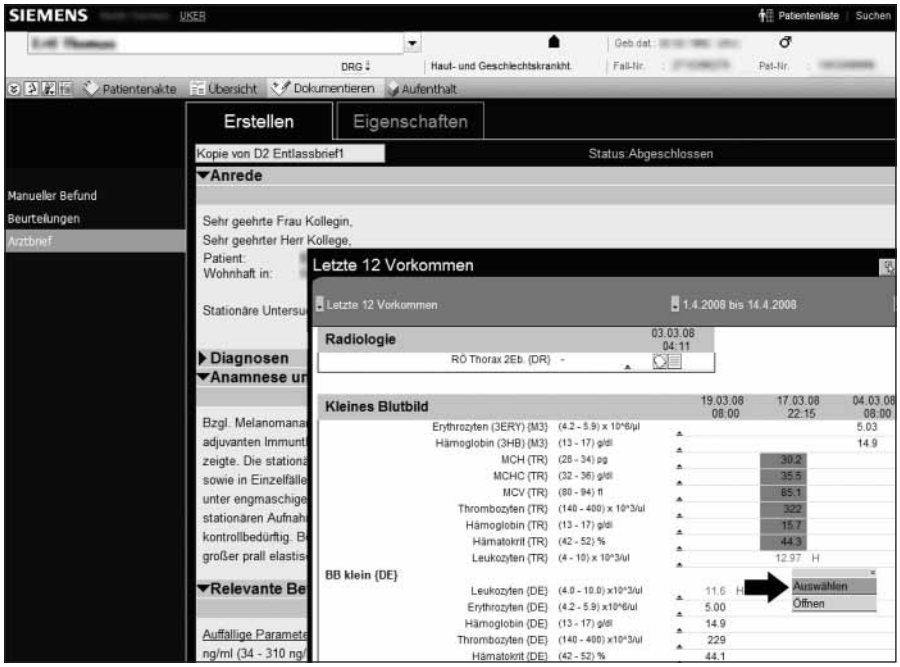

Fig. 2 Text editor and findings in Soarian. Free text is entered using the built-in text editor which offers basic text formatting options and predefined text blocks. Findings which are already stored in the EHR can be interactively selected from the list of findings (marked with an arrow) and included into a discharge letter at predefined positions.

interview, to conform with good interview practices and optimize the reliability of interview outcomes. This approach also minimizes interviewer error or bias, to the maximum extent possible.The open-ended questions for the staff-interviews were related to relevant documents, contact points, duties and responsibilities as well as personal comments (commendation, critique and rating) regarding the discharge letter process and Word/Soarian. The interviews were transcribed or recorded and subsequently reviewed. Interview data and relevant documents were analyzed and scrutinized as appropriate. To complete the analysis, clinical processes were verified empirically by means of observation of hospital personnel performing their daily practical work within the context of the unique conditions which exist in hospitals with emergencies and high workflow variability [47]. To achieve objectivity all interviews, exploration and further analysis of the data were undertaken by the same neutral interviewer, who was involved neither in the discharge letter process nor the discharge letter systems prior to this study.

Surveys of staff confirmed anecdotal evidence that users preferred Word due to the impression that it is easier to use and/or requires less input than Soarian. Taken collectively, we found that critique from different users converged, which can reasonably be accepted as evidence for validity. The arising research question was formulated: "Is there a substantive difference between Word and Soarian in the time and effort it takes to compose a physician discharge letter?"

2.3.2 Step 2: Process Model

By triangulation of different empirical methods [43] – the iteration of data collection, their analysis, reflection, verification and reorganization – an inductive model of the existing discharge letter process was created from qualitative data. The collected data includes different subjective users' narrations, views and opinions, observations by the evaluator, as well as procedures enumerated in the department's quality management handbook. The handbook contains due dates, responsibilities and prototype letters; however, no process model or workflow definition.

The workflows were modeled after the narratives and specifications of the users. Variations and deviations between different users' descriptions of the processes were scrutinized. Depending on the users' review, the process model was either approved, harmonized or deviations were modeled to reflect actual clinical practice; e.g. different physicians' habits, such as document creation in Soarian during dictation already.

Therefore the harmonized process model was constructivisticly modeled using business process modeling notation (BPMN) [48]. The workflow diagrams were supplemented with text descriptions and complemented by staff narratives and researcher observations, thus forming the characteristics containing the normal workflow and its deviations.

All workflows' characteristics were summarized using a BPMN diagram, a textual description, listing of the process steps and their correlation between the systems, screenshots of the systems, a description of special features and problem points; indicators and an aggregated overview were also included. For a complete overview of all workflows refer to [38].

2.3.3 Step 3: Hypothesis and Indicators

Based on the results of step 1, the research question was further refined to make an objectivist comparison of Soarian and Word feasible. The null hypothesis of the difference analysis suggests that the mean value of the respective indicator is equal for Soarian and Word.

Therefore, a set of five indicators, to wit total processing time (indicator 1), system-related waiting time (indicator 2), number of mouse clicks (indicator 3) and number of keyboard inputs (indicator 4), was developed for the hypothesis test. In addition the throughput time (indicator 5) was included, to reconcile the users' assumptions with the due dates defined in the quality management handbook.

The indicators were derived directly from the users' criticism, for precise delineation and quantitative objectification.

Moreover, the business processes and workflows, resulting from the preceding subjectivist analysis, were broken down into more detailed sub-workflows and their workflow steps. The workflow steps corresponding with activities in the respective discharge letter system were mutually mapped onto the indicators.

2.3.4 Step 4: Indicator Measurement

During November and December 2007 an objectivist analysis [41, 43] was undertaken by means of analyzing the users' explicit knowledge through quantitative and qualitative objectivity [44]. Real users and real tasks were evaluated to substantiate this problem impact study [43].

These indicators were measured for each workflow. Twenty actual final physician discharge letters composed by clinic staff were evaluated for this study. For an optimal comparison each letter should have been written in both systems. Duplicating time and effort to do this was declined by clerical staff; therefore, as a compromise, the following letter types were compared:

- letters of day clinic patients, which were still composed with Word
- letters of inpatient cases, composed with Soarian

Aside from the different purpose of these letter types, which are based on the nature of the patient's admission status, both are final physician discharge letters (referenced as "discharge letters" to improve readability). Since both letter formats were developed from the same Word-template (see 2.2.1 and 2.2.2) they are substantively similar in structure, layout, complexity and length. To enable comparison of the length of all evaluated letters in a ratio, the number of words in the content was juxtaposed against the time needed to type the text.

Measurement tools to record points in time varied according to the nature of the process. A stop-watch was employed to measure the processing and system-related waiting time during composition of discharge letters in the users' offices (indicators 1 and 2); a screen-recording of the actual letters' composition (Camtasia Studio™; TechSmith Corporation, Okemos, MI, USA) was utilized for retroactive numeration of the executed user interactions (indicators 3 and 4); and, for verification of throughput time, we used retrieval from Soarian's database (discharge date, completion date of dictation, completion date of discharge letter), supplemented by data manually extracted from the Word-document properties (completion date of preliminary physician discharge notes) (indicator 5).

Processing time was taken in seconds, system-related waiting time was taken in tenths of a second, and throughput time was taken in days; computed mean values were rounded off to one position behind the decimal point. The number of user interactions was enumerated. The indicators' values resulted in a comparison with high objectivity, which also indicates that the granularity of the points in time and the measuring methods themselves were fully appropriate.

For each workflow and each discharge letter system 20 actual discharge letters were measured during routine operation in a total of about 1500 of single measured points in time and about 2000 enumerated user interactions with a negligible variance which supports the assumption of a sufficiently high ratio of reliability. The comprehensive evaluation [38] covers the whole discharge letter process with its six sub-processes and 20 workflows.

2.3.5 Step 5: System Comparison

Word's and Soarian's performance were compared to each other by means of indicators, so-called technical factors [49]. Since the process steps aren't always executed sequentially, the measured values had to be sorted afterwards and assigned to their respective workflow. The mean indicator values of all workflows were combined for statistical analysis in the form of a fictitious discharge letter.

The statistical test was conducted with the level of significance set at 0.05, using the Student t-test for normally distributed data and the Mann-Whitney U-test (non-parametric) for skewed data. Processing and visualization were performed using SPSS™ 15 (SPSS Incorporation, Chicago, IL, USA).

2.3.6 Step 6: Optimization Recommendations

Our purpose in conducting the study was twofold; to objectify user critique for a unique system transition, but also to produce an empirical outcome; making the identification of optimization possibilities feasible. Based on the aggregation of users' narratives, evaluator observations, the process model and the system comparison done before – as well as the evaluators' experience in the field of HIS optimization – recommendations were structured for the newly deployed discharge letter system.

3. Results

3.1 Step 1: Data Acquisition and Research Question

Users' perceptions and information about the discharge letter process was acquired in semi-structured interviews by querying the six ward physicians (physician A through F) and three typists (typist A through C). In general all users were aware of the need to transition from Word to Soarian, in order to establish an integrated system which serves not only the Department of Dermatology, but in the end the whole University Hospital Erlangen. However, the interviews revealed vague criticism:

- Comment 1: "No functionality is missing, but we are not completely happy with Soarian." (typist A)
- Comment 2: "The system is too slow in some points." (typist C)
- Comment 3: "I don't know exactly which (workflow) step could be saved; I just realize it takes too long." (physician C)

We scrutinized this vague criticism by asking for potential problem points in the workflows or the deployed systems. The discharge letter process was "always done like this" with no known potential problems in the workflow. However, during the interviews the first evidence for deviations was revealed; e.g. when and by whom the

discharge letter was generated in Soarian, which depends on the respective physician:

- Comment 4: "I don't generate letters myself, since I don't see a sense in it, just more effort. (…) The findings are entered with 27 clicks and a lot of waiting time. (…) I am used to working with Word; it is fast and I know what and how to do it." (physician C)
- Comment 5: "I generate the letter myself in Soarian and brachiate through the letter by following the text blocks, while selecting the findings and doing the dictation." (physician A)

By in-depth interrogation we were able to get more specific critique regarding the workflows and the discharge letter systems.

- Comment 6: "Soarian is too labor-intensive and too cumbersome. (…) It takes more keyboard inputs and more mouse clicks than Word. (…) Writing a letter (with Word) was easier before …" (typist A)

It became apparent that the particular workflows "check spelling" and "check layout" are "critical" for most of the users, especially since they are repeated for each discharge letter and for several letters a day:

- Comment 7: "We are not content with the spell-checking, since it takes too many clicks. (…) It is an eternal clicking and waiting until the window opens." (typist A)
- Comment 8: "There are too many clicks and it takes too long until the (layout) preview opens. I would also be glad if it wouldn't take more than ten seconds." (physician E)

However, the users did not only comment on a single isolated workflow, but about the whole composition process:

- Comment 9: "It doesn't take long for one single activity, but if you sit in front of the display all day, it sums up." (typist A)
- Comment 10: "Everything is a time factor, maybe a paltry one, but in the end it takes more time." (typist B)
- Comment 11: "Generally, the discharge letter is sent to the general practitioner within two to three weeks." (physician C)

That showed us that all user interactions and system computing times, as tiny as they might be, are important; cumulatively and collectively, they form a comprehensive model. Since the advantage of Word was mentioned several times, we formulated the following research question:

"Is there a substantive difference between Word and Soarian in the time and effort it takes to compose a physician discharge letter?"

3.2 Step 2: Process Model

The process model was created based on the different users' narratives from step 1. As applicable, the workflow was harmonized; if no mutual consent existed among the users' views, deviations were modeled.

The discharge letter is a means to inform the referring physician about recommendations for further treatment and to document medical procedures performed on an inpatient basis. The objectives of the complete discharge letter process are to create both a short preliminary physician discharge note, which is given to the patient during the discharge process, and a final physician discharge letter, which is sent to the referring physician, post-discharge, and usually includes additional findings which often are received at the ward after the patient has been discharged (▶Fig. 3).

The iterative "create discharge letter" sub-workflow is performed in a similar way in Word and Soarian; however, the deviations found during the interviews could be modeled at once. For example, whether the physician creates the letter or not (see Section 3.1, comments 4 and 5) leads to another deviation in "create discharge letter"; also, whether the typist loads the pregenerated discharge letter or generates the discharge letter herself (▶Fig. 4).

After creation, the unapproved discharge letter is saved and transmitted electronically or printed on paper to the assigned physician for initial proofreading and editing. Subsequent to physician approval, the discharge letter is printed for mail delivery. As an aid to managerial oversight, both systems offer the option of printing a work list of incomplete, unapproved and overdue discharge letters; this is done on a weekly basis.

3.3 Step 3: Hypothesis and Indicators

The research question generated by step 1 in the subjectivist analysis was further refined to make a comparison of Soarian and Word practicable: The primary outcome measures were compared by means of a difference analysis: The null hypothesis suggests that the mean value of the respective indicator is equal for Soarian and Word.

$H_0: \mu_{Soarian} = \mu_{Word}$

$H_1: \mu_{Soarian} \neq \mu_{Word}$

where $\mu_{Soarian}$ is the indicator's mean value for Soarian, and μ_{Word} is the indicator's mean value for Word.

User comments led to the definition of key indicators for the discharge letter process. The indicators were directly derived from user critique, as illustrated in the following examples: users repeatedly articulated complaints about the workflow "check layout" for "taking too long" (step 1, comment 8), due to the layout preview opening in Acrobat Reader, which led to the indicators total processing time and system-related waiting time; they voiced specific but subjective criticism of Soarian as being "too labor-intensive and too cumbersome", in that they felt certain it required "more keyboard inputs and more mouse clicks than Word" (step 1, comment 6) to accomplish the same activity; additionally, they disparaged the workflow "check spelling" as "taking too many clicks" (step 1, comment 7), therefore the number of user interactions for each workflow was registered as an indicator. Since the users assumed that the completion of letters is according to defined due dates, the indicator throughput time was included (step 1, comment 11).

The following set of indicators was defined:

- Indicator 1: Total processing time of the workflow based on detailed workflow-steps

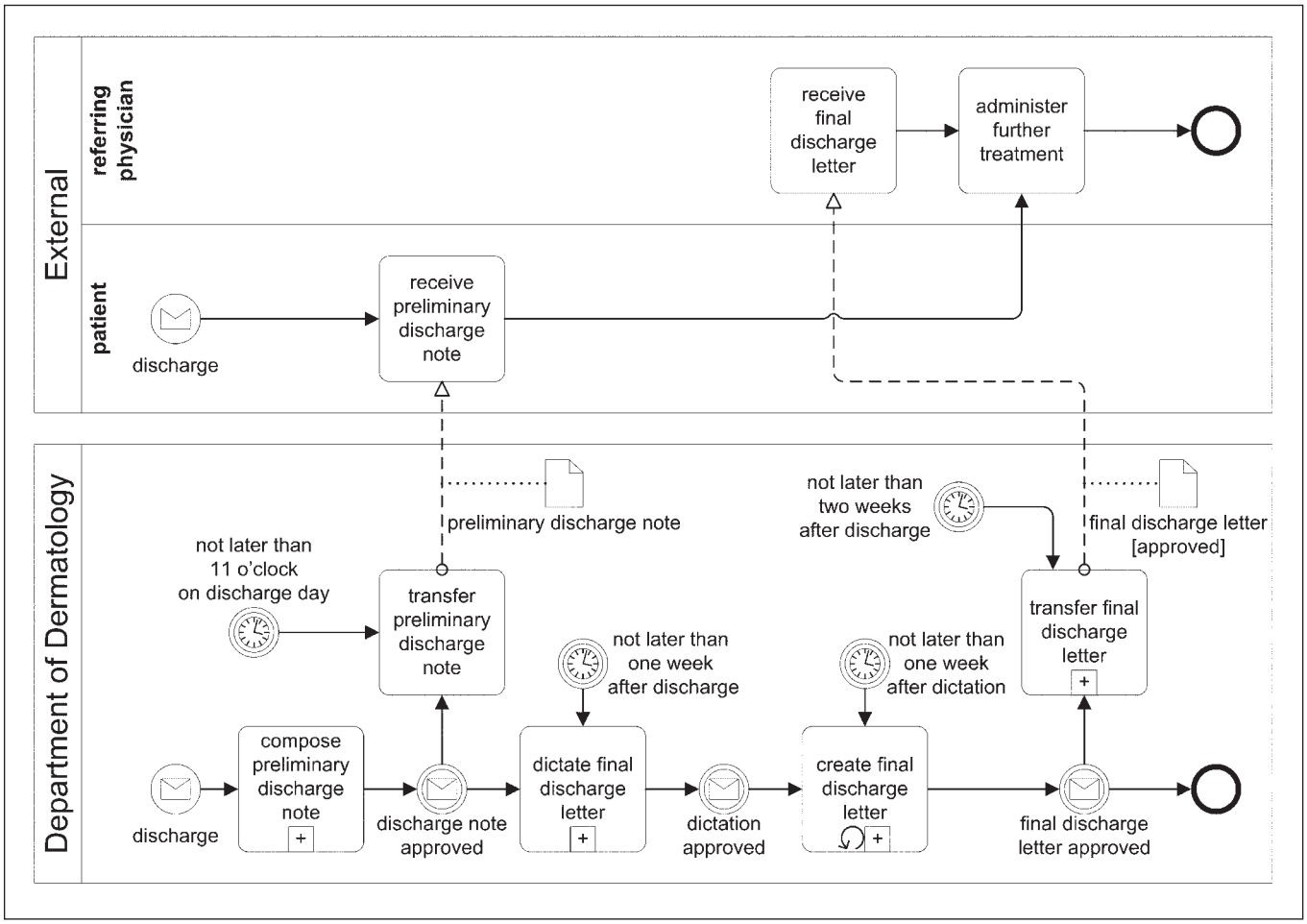

Fig. 3 Physician discharge letter composition process (BPMN diagram). The business process is initiated by the event of a patient's discharge. The ward physician composes the preliminary physician discharge note not later than 11:00 a.m. on discharge day and hands it to the patient. Not later than one week after the patient's discharge, the ward physician dictates the final physician discharge letter. The dictation cassette together with the medical record is forwarded to a typing pool. After an iterative transcription, correction and approval process, the final physician discharge letter is sent by post to the general practitioner not later than two weeks after discharge. The process is composed of several sub-workflows, which can themselves be expanded again in more detailed BPMN diagrams; this is denoted by a "+" symbol within the sub-workflow box.

- Indicator 2: System-related waiting time during the workflow and sub-workflows
- Indicator 3: Number of mouse clicks to complete the workflow
- Indicator 4: Number of keyboard inputs to complete the workflow
- Indicator 5: Throughput time from patient's discharge to completion of the discharge letter, subdivided by throughput times for preliminary physician discharge notes, dictation, and discharge letter

3.4 Step 4: Indicator Measurement

The quantitative indicators throughput-, processing-, system-related waiting time and the number of user interactions were measured for 20 actual discharge letters, examining each workflow for both Soarian and Word.

For the example in ▶Table 1, the measured mean values were 3/8 (Soarian/Word) user interactions, a system-related waiting time of 4.9 s/0.7 s (Soarian/Word) and a total aggregate processing time of 30.6 s/29.4 s (Soarian/Word).

The mean values of indicators 1–4 for all compared sub-workflows of "create discharge letter" are shown in ▶Table 2.

During the interviews for workflow analysis, users commented that discharge letters are "generally" being completed within two to three weeks after discharge of the patient (step 1, comment 11). This statement was cross-checked for all inpatient cases of 2007 (N = 2154) against the due date defined in the department's standard operating procedure for the respective document. The mean values of the throughput time equates to the previously defined indicator 5 (▶Table 3).

3.5 Step 5: System Comparison

The formal hypothesis generated in step 3 was tested, using the measured indicator values from step 4. Accordingly, the whole workflow "create discharge letter" was evaluated.

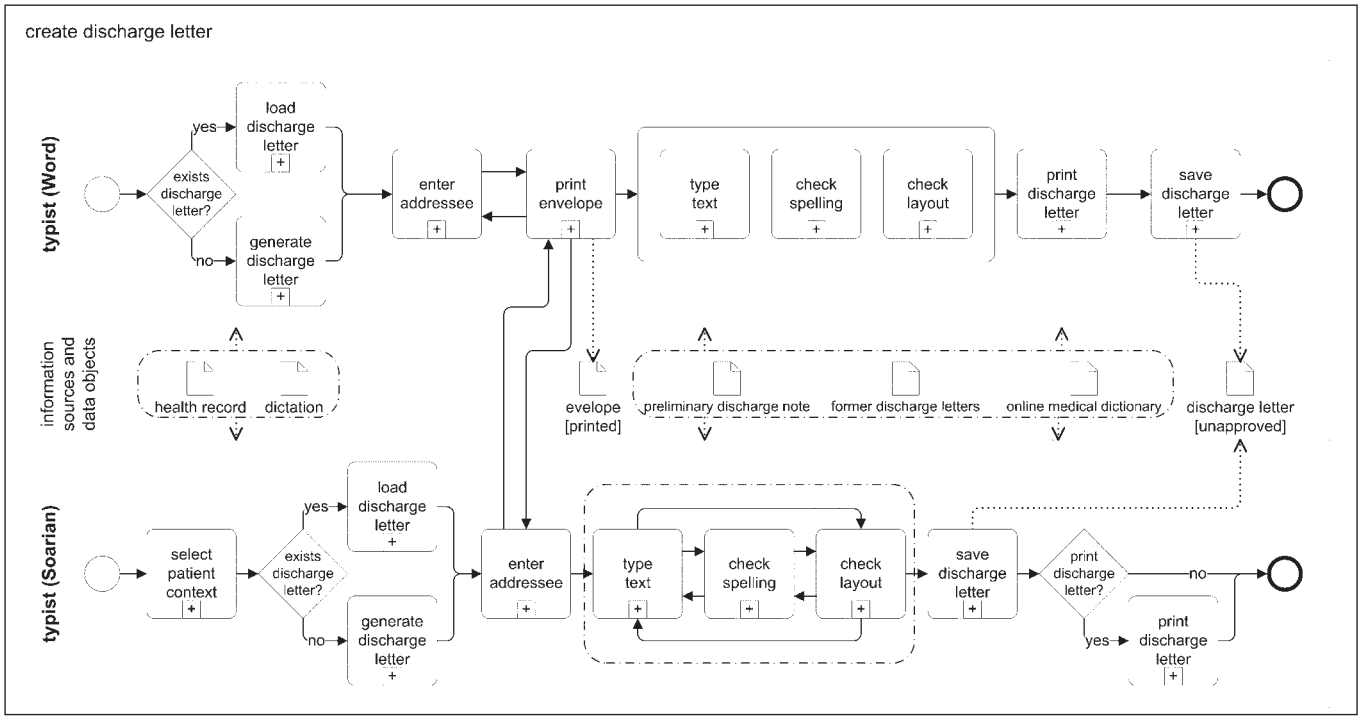

Fig. 4 Sub-workflow "create discharge letter" (BPMN diagram). Using information contained in existing inpatient records, the patient context is selected (Soarian only). The final physician discharge letter is created by using a correspondence template. Addresses are entered by clerical staff into an electronic form (Word) or picked from a list (Soarian), then merged into discharge letters. Envelopes for postal service delivery are printed using Word, since an envelope- and label-printing option is not available in Soarian at this time. Finally, the receipt of the dictation-cassette is also documented electronically. Electronic findings are selected and transferred (Soarian) or copied (Word) into the discharge letter. Writing text as well as spell-checking and layout-review are done in sequential steps (Soarian) respective in parallel without a certain order (Word).

Table 1 Comparison of the „load discharge letter" sub-workflow's steps for the Soarian and Word. The indicators are mapped onto the workflow steps and marked for better readability, using "🖱" for user interaction, "⌛" for system-related waiting time and "🕑" for the total aggregate processing time.

Soarian		Word	
🖱	"Document"	🖱	"Open"
🖱	"Discharge Letter"	🖱 x 6	Choose path
🖱	Select discharge letter from list	🖱	Select discharge letter
⌛ 4.9 s	Discharge letter is loaded and displayed	⌛ 0.7 s	Discharge letter is loaded and displayed
🕑 **30.6 s**	**Processing time**	🕑 **29.4 s**	**Processing time**

Apart from rudimentary differences between both systems, the two sub-workflows primarily criticized by the users (step 1, comments 7 and 8) "check spelling" (Soarian: 75.4 s/Word: 60.7 s; $p = 0.038$) and "check layout" (Soarian: 83.0 s/Word: 23.2 s; $p < 0.001$) showed a significant difference.

The aggregated number of user interactions (ui) to accomplish the workflows in either system showed a significant disparity (Soarian: 77 ui/Word: 69 ui; $p < 0.001$). However, the two critical sub-workflows named above "check spelling" (Soarian: 2 ui/Word: 3 ui; $p < 0.001$) and "check layout" (Soarian: 1 ui/Word: 0 ui; $p < 0.001$) required relatively few user interactions.

The mean value of the aggregated system-related waiting time was 101.8 s with Soarian and 37.2 s with Word, which results in a significant difference of 64.6 s ($p < 0.001$).

For an isolated examination of the creation process for a fictitious discharge letter, the mean value of the aggregated processing time was 2011.7 s with Soarian and 1971.5 s with Word, which results in a statistically insignificant difference of 40.2 s ($p = 0.457$).

3.6 Step 6: Optimization Recommendations

Based on the process model and measured indicator values, several optimizations (see [38] for a comprehensive description) have been recommended for implementation, of which the most important are:

- Optimization of the discharge letter's document definition to enable electronic transfer and interoperability between the hospital and general practitioner; through technical (CDA; cp.

Table 2 Indicators 1–4 of the sub-workflow "create discharge letter". Mean values of processing time, system-related waiting time in seconds and number of mouse and keyboard interactions partitioned by workflow and system. The indicators for "print envelope" are marked equal for both systems, since the envelopes are always printed in Word. Processing time for „type discharge letter" was put in relation to the number of words entered.

	Soarian				Word			
sub-workflows of "create discharge letter"	processing time (s)	waiting time (s) (included)	user interactions		processing time (s)	waiting time (s) (included)	user interactions	
			mouse	keyboard			mouse	keyboard
select patient context	17.3	9.5	4	1	0.0	0.0	0	0
document dictation entry	11.6	6.5	6	0	9.2	0.4	5	1
generate discharge letter	25.0	6.3	8	1	11.8	0.7	7	2
load discharge letter	30.6	4.9	3	0	29.4	0.7	8	0
transfer findings	15.0	13.8	4	0	12.2	0.0	3	2
enter addressee	24.3	3.7	5	1	31.2	0.0	0	3
type discharge letter	1276.0	0.0	14	7	1337.0	0.0	7	7
check spelling	75.4	0.0	2	0	60.7	0.0	3	0
check layout	83.0	6.1	1	0	23.2	0.0	0	0
print discharge letter	18.7	16.9	3	0	18.3	17.5	1	0
save discharge letter	5.6	4.6	2	0	19.5	0.4	8	1
document discharge letter creation	0.0	0.0	0	0	7.6	0.4	4	0
print envelope	27.0	16.7	3	1	27.0	16.7	3	1
review discharge letter	379.5	0.0	1	1	360.9	0.0	0	0
approve discharge letter	9.0	6.1	3	0	23.5	0.4	3	0
assign physician	13.7	6.7	6	0	0.0	0.0	0	0
create discharge letter (summation)	**2011.7**	**101.8**	**65**	**12**	**1971.5**	**37.2**	**52**	**17**

[40]) and structural (cp. [50]) standardization. The discharge letter itself can be standardized using CDA (cp. [51]).

- Optimization of Soarian's response times, especially the processing time and the system-related waiting time of the workflows "check spelling" and "check layout".
- Optimization of the discharge letter processes, by means of comprehensive use of the EHR and Soarian throughout the university hospital to achieve reusability of data and to enable clinical interoperability (cp. [40]); thus on the one hand making more electronic findings available, which can be merged into the discharge letter (cp. [52–54]) and on the other hand justifying the extra effort for composing a proper electronic discharge letter for a comprehensive EHR (cp. [2, 55]).

Table 3 Indicator 5 – Throughput time in days from patient's discharge to completion of the respective document: for all N = 2154 inpatient cases of 2007 regarding preliminary physician discharge notes, dictation, and discharge letter. The quota specifies the percentage of "valid" (existing in electronic form) documents finished by the due date in relation to a patient´s discharge. The remaining documents (difference to 100% quota) were delayed, i.e. valid, but not completed by the due date. The "missing" documents were not available in electronic form for analysis.

	valid	missing	mean (days)	minimum (days)	maximum (days)	due date (days)	quota
discharge note	1039	1115	0.8	–3	61	1	90.6%
dictation	1885	269	17.3	0	199	7	41.3%
discharge letter	1912	242	51.1	2	247	14	9.3%

- Optimization of the workflows through precise delineation and by means of continuous process management (cp. [56, 57]); especially for the purpose of obtaining reliable performance indicators (cp. [58–60]) instead of vague user perceptions.

3.7 Supplement

Several recommendations were made for Soarian's enhancement in step 6, based on the workflow characteristics and the system comparison. The reduction of the system-related waiting times, which is directly connected to the users' critique and which

would result in direct time saving for both clerical staff and ward physicians, has been favorably reviewed by the company; moreover implementations have already been announced for the next version of Soarian™ (2.0 C6; due date October 2009).

At the time of this study the contemporaneous version of Soarian (2.0 C5 HF5) was deployed live at the departments of dermatology, urology, gynecology and trauma surgery. By September 2009 the system was additionally used for discharge letter composition in the departments of neurosurgery, neurology, thoracic surgery, pediatric cardiology, plastic surgery and the University cancer center.

4. Discussion

By addressing the user critique directly using subjectivist methods and by mapping the users' critique onto workflow steps, we derived indicators which can be used for continuous quality assurance. In our extensive review of the literature, we found no comparable study which described the same approach in the area of discharge letters. Publications referencing a similar hospital environment [13, 14, 31] have quantified user critique as well; in particular for the discharge letter composition process [31, 34, 35]. This was conducted as part of user satisfaction and user acceptance evaluation using questionnaires; e.g. Questionnaire of User Information Satisfaction, QUIS [15, 61, 62].

Using BPMN [63], which was already approved suitable for modeling healthcare processes by Lang [48], a complete discharge letter composition process model was created for University Hospital Erlangen's department of dermatology. Common workflow modeling aims at the general workflow; variations, barriers and deviations are described later in the modeling process, if at all [56]. The unique advantage of our direct subjectivist approach for workflow modeling is that the harmonized model, including deviations and optimizations, can be derived promptly from the users' individual and cumulative expertise. To our knowledge, no other published study derived discharge letter composition workflows and its deviations directly from subjectivist data. This model could equally be used in a Business Process Management (BPM) system including a BPM engine, to automate clinical processes, to make processes measurable and to reduce staff workload as demonstrated by Hess [64].

The exploration of user perceptions and the planned system comparison inevitably led to our hypothesis for the difference analysis. Five adequate key indicators were derived directly from the user critique, regarding the discharge letter composition process; moreover, these indicators were mapped onto the workflows and its activities.

From the perspective of business administration previously reported "classical indicators" include customer satisfaction, staff satisfaction, error rates (of products), costs and throughput times [58]. The identified indicators in our study were processing time, system-related waiting time, number of mouse clicks, number of keyboard inputs and throughput time; which shows that objectifying user critique has some parallels in business administration [60], to wit staff satisfaction and throughput time. Throughput time for dictation and discharge letter composition was also measured by Lieb [25] – in a study with the objective to decrease the throughput time – in addition he measured the times for letter creation and signing of the letter, which were not essential for our research focus. Colsman [65] measured the processing time per page, not the total processing time of the discharge letter creation. Larndorfer [13] enumerated the number of mouse clicks for typical workflows in an HIS, though not for discharge letter composition.

Crucially, our study additionally measured the detailed workflow indicators system-related waiting time and number of keyboard inputs. The literature is largely silent about usage of these two indicators regarding the evaluation of discharge letter systems and related user criticism. Accordingly, we can only speculate whether this is because these indicators were not noticed or if they were not measured in studies, because of the acquisition's complexity or for other reasons. We would like to point out: if we had not conducted a subjectivist analysis before, we might have missed an essential indicator such as system-related waiting time.

The system comparison of the deployed discharge letter systems Word and Soarian showed both a partial discrepancy and demonstrated consistency between users' perceptions and objective results. Although some user critique differs from objectively measured values, we found good correlation between user critique and increased system-related waiting time and therefore assume sufficient methodical validity. The deployed discharge letter systems differ essentially through their respective unstructured and structured composition of discharge letters, which is also reflected in the processing time of critical workflows. The ostensible dependence between users' criticism of the discharge letter process as being "too labor-intensive" and the actual number of user interactions could be shown; however, the enumerated user interactions were negligible in contrast to the processing times.

The isolated examination of a fictitious discharge letter's composition results in a statistically insignificant difference of 40.2 s in favor of Word, which must be put in relation to a total processing time of 2011.7 s for Soarian versus 1971.5 s for Word. The differences regarding number of user interactions (Soarian 77 ui vs. Word 69 ui) and aggregated system-related waiting time (Soarian 101.8 s vs. Word 37.2 s), by contrast, are significant. In this respect, Soarian offers synergy effects, particularly through the interoperability and reusability of discharge letter content. Additional optimizations also stand to be achieved through increased system performance, as well as a conscientiously applied program of continuous quality assurance.

To our knowledge, the only other study evaluating discharge letter composition using Soarian was conducted by Colsman [65]. He detected an inverse relation of the aggregated processing time per page of a discharge letter: here Soarian was faster by 3.4 minutes (14 %). However, his study had a different research focus, to wit the processing time of a discharge letter from the perspective of business administration; possible reasons for the different outcome are that Colsman evaluated a different version of Soarian (2.0 C5 HF10 instead of

2.0 C5 HF 5), different coverage of workflows (dictation through shipping of discharge letters instead of discharge letter creation) and different reference base (mean value per-page instead of per-letter). Moreover, Colsman did not measure any of the other indicators which we evaluated.

Interpretation of the indicators in regard to user critique leads directly to our assumption that the subjective view of staff on a system's performance can often not be documented by objective measurements; a position which is also supported by Colsman [65]. For a system user waiting for a system response is usually much more onerous than additional mouse clicks or keystrokes; even when the total time spent on performing a particular process is shorter, because the system performs "work in the background" during this waiting time, which does not require extra effort by the user.

Moreover, a discrepancy exists between user assumptions of "two to three weeks" and the objective throughput time of 51.1 days; instead of the defined due date of 14 days, which is only followed in 9.3% of cases. In the literature, general problems in the throughput of the discharge letter process range from "delayed by one to two weeks" [3] to "not available" [20]. Lieb [25] found a shorter throughput time of 29 days, which was decreased to 11 days by workflow optimization; with a defined due date of 10 days. O'Leary [27] found an even more impressive throughput time with 72.6% of the discharge letters completed within three days; his "ultimate goal is to have 100% of discharge summaries completed within three days", unfortunately the study description does not clarify whether the "discharge summary" equates to our "final discharge letter" or "preliminary discharge note". The same applies to Paterson [26] who found a rate of 39.1% completed on the day of discharge, 85.5% after two days. 90.6% of the preliminary discharge notes in our study were completed on the day of discharge. It is essential to increase efficiency by reducing throughput time by means of HIS [66].

To obtain the synergy effects of Soarian within University Hospital Erlangen, its clinical workflow management system will be used comprehensively throughout the university hospital's clinical framework. Synergy effects were appraised by Stead [67] and Hripcsak [68] within Integrated Advanced Information Management Systems (IAIMS), which created appreciable added value through interaction of IT applications in large medical centers. Optimal gain from clinical information systems usually cannot be achieved during transition periods while traditional workflows and traditional system usage are still being pursued in one area, at the same time as a new system is being implemented in other areas. Thus a quick and exclusive diffusion of Soarian needs to be enforced, once the recommended optimizations have been implemented.

Some of our optimization recommendations have already been reviewed by the company and implementations have recently been announced for the next live version of Soarian (2.0 C6). Moreover, the initially defined indicators resulted in objective evidence to substantiate the validity of evaluated user critique and are planned to be used for continuous quality assurance. Thus, our study has already led to a practical outcome. Due to the exact definition of workflows and activities, and by means of thoroughly mapping the indicators, measurements can be repeated if the method is used on the same workflows again; for example taking our results as a baseline for an intervention study as demonstrated by Lieb [25].

5. Conclusions

Discussing unspecified, vague user critique can be problematic. In the end, equally valid opinions could be juxtaposed, so that any constructive discussion or optimization is undermined before it starts. User perceptions are often no legitimate basis for delaying or refusing to implement upgrades to existing information technology, or installing new systems. This is not to say that user critique should be discounted. To enhance the prospects of successfully deploying HIS upgrades, users need to be consulted and their subjective views objectified before even thinking about optimizations. To make a factual discussion possible, "tangible" indicators must be adequately defined and appropriately measured.

The results and experiences of our study, regarding the physician discharge letter composition process in the Department of Dermatology at University Hospital Erlangen, Germany, resolved into four important points:

1. A combination of subjectivist and objectivist methods can be used to objectify user critique, thereby making it tangible for future continuous quality assurance. Our subjectivist analysis led to an adequate harmonized model of the discharge letter process, which was enhanced and complemented by the objectivist analysis through the use of quantified indicators. Significantly, to our knowledge, no other publication used system-related waiting time as an indicator to evaluate physician discharge letter composition; an indicator which led to significant outcome and which we identified through utilization of subjectivist methods.
2. Mapping of user critique onto indicators takes time, effort and intuition. In our study we specified user critique and mapped it onto indicators, to measure time and effort of certain workflow activities, thus objectifying the criticism. Indicators were measured in several thousand points of time, mostly manually. The selected and applied indicators were deemed valid for future automation and continuous quality assurance.
3. Continuous quality assurance requires indicators, which should be standardized and captured automatically. Management of information systems and clinical processes – of which this paper's discharge letter process is an example – requires the definition of clearly delineated and commonly agreed upon key indicators. In addition, since a controlling instrument can't wait for a few thousand points in time to be taken manually, the measurement of the indicators must be automated.
4. Synergy effects are frequently only visible under a wider scope. The reasons for deployment of an integrated information system – Soarian™, in our case

study – are expected opportunities for synergy effects. Since, in our study, users complained about the additional work demands imposed by creation of physician discharge letters and mandated use of the related systems, we focused on the workflows' details, thus losing the positive hospital-wide synergy results for presentation to our users. We found that staff response was largely positive when it was possible to demonstrate that the short-term inconvenience of learning a new system would result in long-term benefits to clinic staff and to the hospital, in terms of actually reducing administrative burdens.

A priori results are valid only for the environment in which an evaluation took place. However, since user critiques could be objectified effectively – independent of the outcome proving or disapproving the users' critiques – we believe that the indicators can be used to objectify user critique for discharge letter processes in other hospitals; and also, that the method as is can be extrapolated for other processes.

Based on our evaluation experience we consider the following six-step approach applicable to objectify user critique in general:

- Step 1: Acquire user critique using subjectivist methods and identify research questions for in-depth evaluation
- Step 2: Create a workflow model of the evaluated system (based on step 1)
- Step 3: Define a formal hypothesis and indicators, which reflect the user critique (based on steps 1 and 2)
- Step 4: Measure all indicators (based on step 3)
- Step 5: Analyze the results and test the hypothesis (based on step 4)
- Step 6: Optimize the system based on the subjectivist and objectivist results (based on steps 1, 2 and 5)

Conscientious planned solicitation of user critique should form the core of any medical informatics health system installation or upgrade. The advantages to a medical facility of obtaining end-user acceptance of and satisfaction with technological innovation can make the difference between achieving organizational objectives or diminishing the anticipated return on investment.

By following the six steps outlined above, a medical informatics department can map user critique on mission critical indicators and objectively measured values. Most advantageously, mapping of user critique eventually leads to optimizations and automated indicators, which generate indispensable information for continuous quality assurance. The good results we achieved at University Hospital Erlangen prove the approach and demonstrate the significance of evaluation studies in healthcare as a key component in generating important forward-looking management information.

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References

1. Modler H. Qualitätsmanagement: Der Arztbrief. Göttingen: Universität Göttingen, Bereich Humanmedizin, Medizinische Informatik; 2005 (updated 2005, cited 28.8.2007). Available from: http://www.mi.med.uni-goettingen.de.
2. Semler SC. Automatische Arztbriefschreibung – was sollte sie können, wie weit darf sie gehen? In: Wehrs H, editor. Der Computer-Führer für Ärzte. 9th ed; 2001.
3. Spießl H, Cording C. Kurz, strukturiert und rasch übermittelt: Der "optimale" Arztbrief. Deutsche Medizinische Wochenschrift 2001; 126: 184–187.
4. Waegemann CP. Where is eHealth going? 2008 (updated 2008; cited 21.10.2008). Available from: http://www.medrecinst.com/.
5. Collen MF. Fifty years in medical informatics. Methods Inf Med 2006; 45 (Suppl 1): 174–179.
6. Klar R. Selected impressions on the beginning of the electronic medical record and patient information. Methods Inf Med 2004; 43 (5): 537–542.
7. Peterson HE. From punched cards to computerized patient records: a personal journey. Methods Inf Med 2006; 45 (Suppl 1): 180–186.
8. Roberts MS, Dreese EM, Hurley N, Zullo N, Peterson M. Blending administrative and clinical needs: the development of a referring physician database and automatic referral letter. Proc Annu Symp Comput Appl Med Care 1991. pp 559–563.
9. Aarts J, Berg M. Same systems, different outcomes – comparing the implementation of computerized physician order entry in two Dutch hospitals. Methods Inf Med 2006; 45 (1): 53–61.
10. Aarts J, Doorewaard H, Berg M. Understanding implementation: the case of a computerized physician order entry system in a large Dutch university medical center. J Am Med Inform Assoc 2004; 11 (3): 207–216.
11. Southon G, Sauer C, Dampney K. Lessons from a failed information systems initiative: issues for complex organisations. Int J Med Inform 1999; 55 (1): 33–46.
12. Ash JS, Anderson JG, Gorman PN, Zielstorff RD, Norcross N, Pettit J, et al. Managing change: analysis of a hypothetical case. J Am Med Inform Assoc 2000; 7 (2): 125–134.
13. Larndorfer R. Evaluation des klinischen Informationssystems an der Universitätsklinik für Unfallchirurgie und Sporttraumatologie Innsbruck. Innsbruck: Private Universität für Gesundheitswissenschaften, Medizinische Informatik und Technik; 2005.
14. Lechleitner G, Pfeiffer KP, Wilhelmy I, Ball M. Cerner Millennium: the Innsbruck experience. Methods Inf Med 2003; 42 (1): 8–15.
15. Bürkle T, Ammenwerth E, Prokosch HU, Dudeck J. Evaluation of clinical information systems. What can be evaluated and what cannot? Journal of Evaluation in Clinical Practice 2001; 7 (4): 373–385.
16. Bürkle T. Quality of Healthcare: The Role of Informatics. Stuttgart 2003. pp 235–239.
17. Archbold RA, Laji K, Suliman A, Ranjadayalan K, Hemingway H, Timmis AD. Evaluation of a computer-generated discharge summary for patients with acute coronary syndromes. Br J Gen Pract 1998; 48 (429): 1163–1164.
18. van Walraven C, Laupacis A, Seth R, Wells G. Dictated versus database-generated discharge summaries: a randomized clinical trial. Cmaj 1999; 160 (3): 319–326.
19. Lissauer T, Paterson CM, Simons A, Beard RW. Evaluation of computer generated neonatal discharge summaries. Arch Dis Child 1991; 66 (4 Spec No): 433–436.
20. Bolton P. A quality assurance activity to improve discharge communication with general practice. J Qual Clin Pract 2001; 21 (3): 69–70.
21. Moorman PW, Branger PJ, van der Kam WJ, van der Lei J. Electronic messaging between primary and secondary care: a four-year case report. J Am Med Inform Assoc 2001; 8 (4): 372–378.
22. Callen JL, Alderton M, McIntosh J. Evaluation of electronic discharge summaries: a comparison of documentation in electronic and handwritten discharge summaries. Int J Med Inform 2008; 77 (9): 613–620.
23. Walker CA. Dictated versus hand-written accident and emergency discharge documents. Emerg Med J 2007; 24 (1): 67.
24. Roth-Isigkeit A, Harder S. Die Entlassmedikation im Arztbrief. Medizinische Klinik 2005; 100 (2): 87–93.
25. Lieb K, Trieschmann S, Buhl C, Vielhaber K, Mehraein S, Härter MM. Verkürzung der Übermittlungsdauer von Arztbriefen stationär behandelter Patienten in der Psychiatrie und Psychotherapie. Nervenarzt 2007; 78: 322–327.
26. Paterson JM, Allega RL. Improving communication between hospital and community physicians. Feasibility study of a handwritten, faxed hospital dis-

charge summary. Discharge Summary Study Group. Can Fam Physician 1999; 45: 2893–2899.
27. O'Leary KJ, Liebovitz DM, Feinglass J, Liss DT, Evans DB, Kulkarni N, et al. Creating a better discharge summary: improvement in quality and timeliness using an electronic discharge summary. J Hosp Med 2009; 4 (4): 219–225.
28. Ash JS, Berg M, Coiera E. Some unintended consequences of information technology in health care: the nature of patient care information system-related errors. J Am Med Inform Assoc 2004; 11 (2): 104–112.
29. Ash JS, Sittig DF, Dykstra RH, Guappone K, Carpenter JD, Seshadri V. Categorizing the unintended sociotechnical consequences of computerized provider order entry. Int J Med Inform 2007; 76 (Suppl 1): 21–27.
30. Patel VL, Kushniruk AW. Understanding, navigating and communicating knowledge: issues and challenges. Methods Inf Med 1998; 37 (4–5): 460–470.
31. Ammenwerth E, Kaiser F, Bürkle T, Gräber S, Herrmann G, Wilhelmy I. Evaluation of user acceptance of data management systems in hospitals – feasibility and usability. Proceedings of the 9th European Conference on Information Technology Evaluation 2002. 2002. pp 31–38.
32. Ammenwerth E, Mansmann U, Iller C, Eichstadter R. Factors affecting and affected by user acceptance of computer-based nursing documentation: results of a two-year study. J Am Med Inform Assoc 2003; 10 (1): 69–84.
33. Ammenwerth E, Eichstädter R, Haux R, Pohl U, Rebel S, Ziegler S. Systematische Evaluation von Pflegedokumentationssystemen – Studienprotokoll und erste Ergebnisse. Heidelberg: Bericht der Abteilung Med. Informatik 2/1999; 1999.
34. Ammenwerth E, Kaiser F. Evaluation der Benutzerzufriedenheit mit der rechnergestützten Arztbrief- und Befundschreibung. Innsbruck: Private Universität für Medizinische Informatik und Technik Tirol; 2002.
35. Engel P. Evaluation der Einführung der elektronischen Arztbriefschreibung am UKM. Münster: Westfälische Wilhelms-Universität Münster; 2004.
36. Haux R, Seggewies C, Baldauf-Sobez W, Kullmann P, Reichert H, Luedecke L, et al. Soarian – workflow management applied for health care. Methods Inf Med 2003; 42 (1): 25–36.
37. Universitätsklinikum Erlangen. Universitätsklinikum Erlangen – Jahresbericht 2007. Erlangen; 2008.
38. Oschem M. Evaluation und Schaffung eines objektivierbaren Vergleichs von Methoden zur Optimierung der Arztbriefschreibung in der Hautklinik des Universitätsklinikums Erlangen; PhD Thesis. Erlangen: Friedrich-Alexander-Universität Erlangen-Nürnberg; 2009.
39. Heitmann KU, Kassner A, Gehlen E, Görke HJ, Heidenreich G. Arztbrief auf Basis der HL7 Clinical Document Architecture Release 2 für das deutsche Gesundheitswesen – Implementierungsleitfaden. Berlin: Verband der Hersteller von IT-Lösungen für das Gesundheitswesen VHitG; 2006 (updated 2006, cited 27.8.2007). Available from: http://download.vhitg.de.
40. Bludau HB, Wolff A, Hochlehnert AJ. Presenting XML-based medical discharge letters according to CDA. Methods Inf Med 2003; 42 (5): 552–556.
41. Ammenwerth E. Die Bewertung von Informationssystemen des Gesundheitswesens. Innsbruck: Private Universität für Medizinische Informatik und Technik Tirol; 2003.
42. Krallmann H, Frank H, Gronau N. Systemanalyse in Unternehmen. 3rd ed. München: Oldenbourg; 1999.
43. Friedman CP, Wyatt JC. Evaluation Methods in Biomedical Informatics. 2nd ed. Hannah KJ, Ball MJ, editors. New York: Springer; 2006.
44. House ER. Evaluating with validity. Beverly Hills: Sage Publications; 1980.
45. Burkle T, Kuch R, Prokosch HU, Dudeck J. Stepwise evaluation of information systems in an university hospital. Methods Inf Med 1999; 38 (1): 9–15.
46. Ammenwerth E, Kaiser F, Wilhelmy I, Hofer S. Evaluation of user acceptance of information systems in health care – the value of questionnaires. Stud Health Technol Inform 2003; 95: 643–648.
47. Ehlers F, Ammenwerth E, Eichstädter R, Haux R, Kruppa B, Parzer P, et al. Unterstützung der Organisation des Behandlungsprozesses in der Kinder- und Jugendpsychiatrie – Ist- und Schwachstellenanalyse. Universitätsklinikum Heidelberg, Abt. Medizinische Informatik; 2001.
48. Lang M, Bürkle T, Laumann S, Bauer J, Prokosch HU. Modeling the Radiology Workflow: A hands-on Comparison of established Process Modeling Languages. 51. Jahrestagung der Deutschen Gesellschaft für Medizinische Informatik, Biometrie und Epidemiologie 2006; Leipzig. 2006.
49. Brender J. Evaluating success and failure factors in health information systems development. MIE 2006; 2006: 280–285.
50. Prokosch HU, Engelmann U, Haas P, Handels H, Schug SH, Steyer G, et al. GMDS-Thesenpapier zur telematischen Vernetzung von Versorgungseinrichtungen im deutschen Gesundheitswesen. GMDS; 2001 (updated 2001, cited 31.8.2007). Available from: http://www.imi.med.uni-erlangen.de.
51. Heitmann KU, Schweiger R, Dudeck J. Discharge and referral data exchange using global standards – the SCIPHOX project in Germany. Int J Med Inform 2003; 70 (2–3): 195–203.
52. Hüske-Kraus D. Text generation in clinical medicine – a review. Methods Inf Med 2003; 42 (1): 51–60.
53. Kannry J, Moore C, Karson T. Discharge communique: use of a workflow byproduct to generate an interim discharge summary. AMIA Annu Symp Proc 2003. pp 341–345.
54. Prokosch HU. Prozessoptimierung durch moderne Krankenhaus-Informations- und Workflowsysteme. In: Eberspächer J, Picot A, Braun G, editors. EHealth: Innovations- und Wachstumsmotor für Europa – Potenziale in einem vernetzten Gesundheitsmarkt. Berlin: Springer; 2006.
55. Laerum H, Ellingsen G, Faxvaag A. Doctors' use of electronic medical records systems in hospitals: cross sectional survey. Bmj 2001; 323 (7325): 1344–1348.
56. Becker J, Kugeler M, Rosemann M. Prozessmanagement – ein Leitfaden zur prozessorientierten Organisationsgestaltung. Berlin-Heidelberg: Springer; 2000.
57. Hirzel M, Kühn F, Gaida I. Prozessmanagement in der Praxis. Wiesbaden: GWV Fachverlage; 2008.
58. Friedag HR, Schmidt W. Balanced Scorecard – mehr als ein Kennzahlensystem. Freiburg: Haufe; 1999.
59. Müller U, Ammenwerth E, Brigl B, Gräber S, Gruetz R, Häber A, et al. Überwachung als Aufgabe des Informationsmanagements im Krankenhaus. GMS Med Inform Biom Epidemiol 2008; 2008 (4: Doc04).
60. Ament-Rambow C. Prozesscontrolling – Möglichkeiten und Grenzen. Krankenhaus Umschau 2000; 2000 (4): 266–269.
61. Chin J, Diehl V, Norman K, editors. Development of a Tool Measuring User Satisfaction of the Human-Computer Interface. Conference on Human Factors in Computing Systems 1988; Washington, D.C.
62. Boy O, Ohmann C, Aust B, Eich HP, Koller M, Knode O, et al. Systematic evaluation of user satisfaction of physicians with a hospital information system – initial results. Stud Health Technol Inform 2000; 77: 518–522.
63. White SA. Process Modeling Notations and Workflow Patterns. IBM Corporation; 2004 (updated 2004, cited 13.2.2008). Available from: http://www.bpmn.org.
64. Hess R. The missing link to success: using a business process management system to automate and manage process improvement. J Healthc Inf Manag 2009; 23 (1): 27–33.
65. Colsman A, Kunzmann U, Seggewies C, Mahler V. Arztbriefschreibung in der Dermatologie im Rahmen eines elektronischen Patientendaten-Mangements – Pilotuntersuchung unter medizinisch-ökonomischen Gesichtsspunkten. Der Hautarzt 2009. pp 1–5.
66. Schabetsberger T, Ammenwerth E, Andreatta S, Gratl G, Haux R, Lechleitner G, et al. From a paper-based transmission of discharge summaries to electronic communication in health care regions. Int J Med Inform 2006; 75 (3–4): 209–215.
67. Stead WW. The evolution of the IAIMS: lessons for the next decade. J Am Med Inform Assoc 1997; 4 (2 Suppl): S4–9; discussion S10–1.
68. Hripcsak G. IAIMS architecture. J Am Med Inform Assoc 1997; 4 (2 Suppl): S20–30.