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Implementation of a Patient Data Management System – An evaluation study of workflow alterations

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Abstract

This paper describes a combined evaluation approach for an information system on intensive care units. Staff self assessment of time needed for documentation activities during admission, daily treatment and discharge/transfer has been compared to a workflow analysis which demonstrated that the system eliminated process steps mainly in daily documentation activities. Interestingly, nursing staff reported major time savings rather during discharge/transfer than in daily documentation, whereas physicians noticed no time savings at all. We conclude that combining workflow analysis with either self assessment of time needed or alternatively appropriate time measurements or both increases insight into organizational changes and their implications after system implementation.

Keywords:

Evaluation, Workflow, Patient data management system.

Introduction

Implementation of a clinical information system does not only concern technical issues but is driven by operational, strategic, cultural or even political changes in the respective organization where the system is introduced. System failures can often be blamed on insufficient change management [1,2]. Berg even stated that implementation of a patient care information system can never be fully planned and controlled due to ongoing organizational changes in a process of mutual transformation [3].

Numerous evaluation studies found improvements after implementation of an information system but others couldn't confirm these findings (see e.g. [4,5,6,7,8] with focus on intensive care environments). Some studies demonstrated an impairment of communication and organization issues, with the potential of system failure or even endangering of patients [9,10].

With regard to Patient Data Management Systems (PDMS) for Intensive Care Units (ICU) there are few studies comparing modifications e.g. in organization and workflows before and after implementation of an information system. We found several studies [11,12,13] dealing with the development of new types of role- and activity-dependent respectively cognitive workflow models. Only Cheng et al [14] compare workflows before and after implementation of a CPOE system on ICU.

With the implementation of a PDMS in one ICU of Erlangen University Hospital we expected improvements in all areas where data could be reused, e.g. reuse of ADT data and automated data transfer from patient monitoring and respirators. We expected more work in all areas where previous paper documentation had now to be done tediously on computer.

The objective of this study was to analyze how our expectations would be met, which activities in the documentation workflow did change and how these workflow alterations correspond to time needed for clinical documentation.

Materials and Methods

The study took place between October 2006 and October 2007 in the Interdisciplinary Operative ICU (IOI) of Erlangen University Hospital, Germany. The IOI has 25 beds and cares for approximately 2000 patients respectively 6800 patient-days per year. In October and November 2006 a commercial PDMS (Dräger ICM) was stepwise introduced. It was fully operational for all 25 beds in December 2006.

A multifocus evaluation study consisting of time measurements, questionnaires and documentation workflow analysis was performed before and after system introduction. The questionnaire was distributed 3 times, namely before (t1), 3 months after (t2) and 12 months after implementation of the PDMS (t3). Among others it included a self assessment of time needed for different documentation activities. The questionnaire described decisively which activities should be assessed (e.g. all documentation activities around admission of a patient) giving explicit examples for physicians, nurses and clerks respectively. We asked to quote the total time needed to perform those activities for one single patient during one shift within the interval options less than 10 minutes, 10-19 minutes, 20 to 29 minutes, 30 to 39 minutes, 40 to 49 minutes and more (with the option to enter a precise number). From the returned questionnaires we calculated a mean value of time spent.

We analyzed documentation workflows before and after implementation of the PDMS and documented them using the software Aris® from ids Scheer. Workflow analysis was performed in two steps. In the first phase one person observed the activities and documented them over several weeks. The same person collected information on all kind of paperwork done on the ICU and the computer systems which were employed before PDMS implementation. This resulted in a first set of pre-PDMS workflow models. In the second phase those models have been reviewed and rectified together with staff members (physicians, nurses, medical clerks) of the ICU. A second similar analysis was performed 3 months after PDMS implementation.

For workflow analysis we used the method described by Pomberger/Gerken [15,16] which usually comprises seven steps:

1. *Analysis of structure.* Comprises organizational structures / hierarchies, number and qualification of staff and relationships to other divisions of the corporation.
2. *Analysis of forms and paperwork.* Systematic collection and analysis of all forms and paperwork with a formal description for each form and its workflow.
3. *Analysis of data items.* Systematic collection and analysis of all data items and information systems in which those data are applied or produced.
4. *Analysis of atomic actions.* Systematic collection and analysis of all process steps which are not further decomposed. For each process step responsible person, forms used and data required are recorded.
5. *Analysis of workflows.* Systematic collection of all complex action sequences based on the process steps analyzed in the previous stage.
6. *Analysis of communication structures.* Systematic definition of a communication matrix, illustrating all communication processes and information flows between different partners based on the first 5 analysis steps
7. *Analysis of weak points.* The identification of weak points aims at providing the basis for future optimization.

For the current project we restricted this analysis to Step 1 to 5 focusing on documentation workflows. Activities of nursing or medical care were omitted.

Workflow diagrams were arranged according to the Aris model [17] with a four level depth of hyperlinked workflows. We used value-added-chain models on level one and two, process-matrix models on level three and event-driven-process-chain models on level four. From these resources we synthesized parallel workflow diagrams in order to compare the status before and after PDMS implementation.

Results

Self assessment of documentation time

Nurses returned 42 of 92 (t1), 29 of 96 (t2) and 23 of 97 (t3) questionnaires. Physicians returned 11 of 15 (t1), 9 of 16 (t2) and 12 of 18 (t3) questionnaires. The average response rate was relatively low with 33% for nurses and 65% for physicians.

Figures 1 and 2 demonstrate the results of time estimations. While physicians did not estimate any relevant time savings for any of the activities such as admission, daily activities and patient transfer/discharge, nurses reported a continuously decreasing time spent for daily documentation activities (down from a mean of 41 at t1 to 31 minutes at t3) and a quickly decreasing time spent for documentation activities around patient discharge (down from 37 minutes to 11 respectively 13 minutes at t2 and t3).

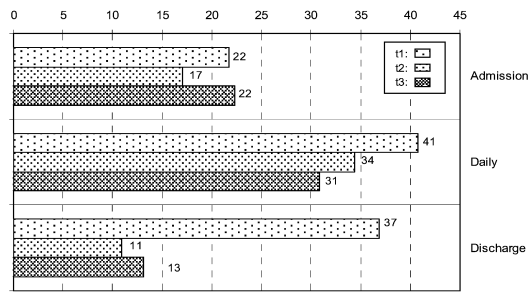

Figure 1- Nurses: estimated time needed in one shift for documenting one patient at t1, t2 and t3 (minutes)

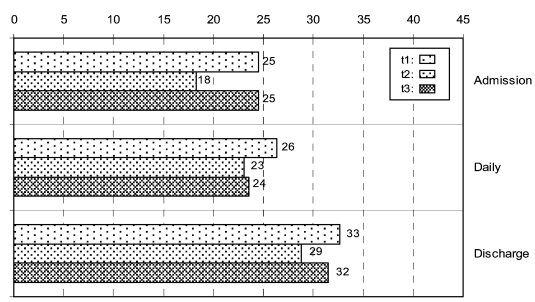

Figure 2-Physicians: estimated time needed in one shift for documenting one patient at t1, t2 and t3 (minutes)

Workflow analysis before and after PDMS implementation

We obtained a total of 29 workflow models for administrative activities of ICU staff before and 25 after PDMS implementation. We grouped them under the high level process-chain steps “admission”, “daily activities” and “discharge”. Together

with organizational view and data view models we ended up with a total of 61 diagrams before and after PDMS implementation. From these resources we synthesized 27 parallel workflow diagrams in order to compare the status before and after PDMS implementation. Figures 3 and 4 demonstrate two examples of such parallel workflow diagrams.

As shown in figure 3 nursing documentation activities for a blood gas analysis (a frequent process in an ICU) have been simplified with the implementation of the PDMS. Previous process steps such as printout of results from the BGA machine and sticking those paper results into the patient paper record have been eliminated after PDMS implementation due to automated data transfer, thus simplifying this workflow.

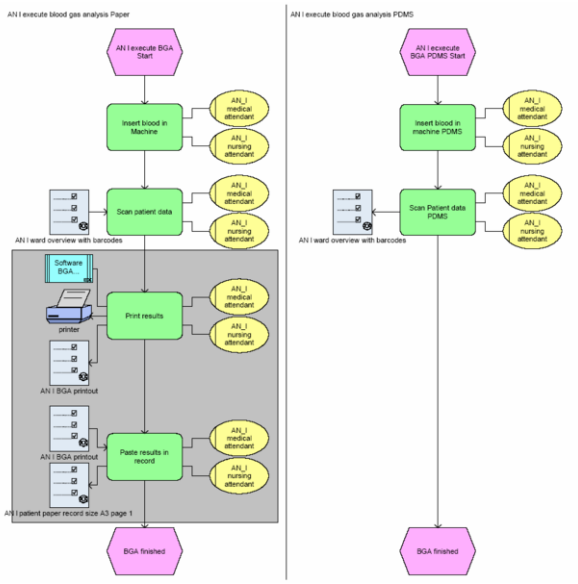

Figure 3- event-driven-process-chain "execute blood gas analysis" and related documentation steps. Left before, right after PDMS implementation

We also found workflows which have been extended. Figure 4 may serve as an example illustrating administrative process steps for admission of a new patient to the ICU.

In the former paper-based workflow the patient arrives on the ward with an empty paper record or the latest available paper record in case of previous admission. No further process steps were required. After PDMS implementation however a new electronic record had to be created for each patient upon arrival in order to start the clinical documentation. Creation of this electronic record comprises working in two software applications. In the generic hospital information system a short electronic admission procedure for the patient and the creation of a new follow-up case is necessary. In the PDMS the new patient case information must be imported and a bed must be assigned. In addition a third specialized ICU software application was used to collect essential reimbursement data. Later this last process step could be performed using new enhanced functionalities of the PDMS thus substituting this activity.

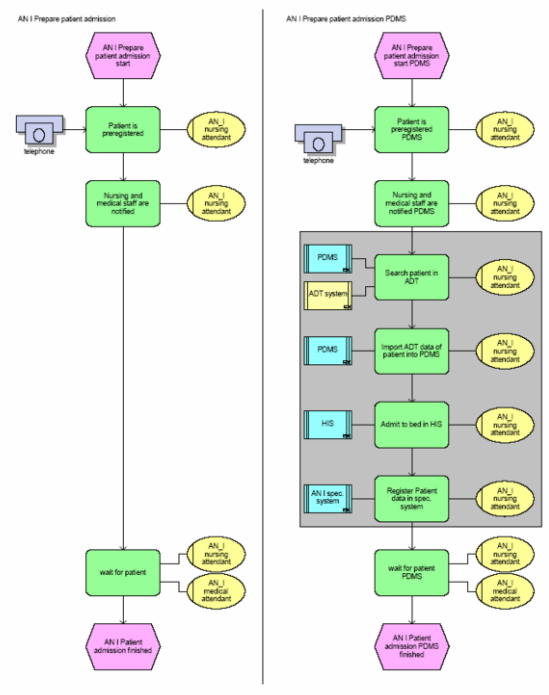

Figure 4 - event-driven-process-chain" prepare patient admission". Left before, right after PDMS implementation

The 27 parallel workflows can be divided into 5 workflows concerning "patient admission", 16 workflows for "daily activities" and 5 workflows concerning patient "discharge or transfer". A top level workflow links these three groups together. Summarizing we detected a multitude of workflow alterations within the 27 parallel workflows.

Eighteen workflows were found to be at least one process step shorter after PDMS implementation, six were of equal length and three workflows had grown considerably (table 1). We noticed shorter workflows in fields such as automated data import from medical equipment (see figure 3), but also in areas where documents could be composed semi-automatically with the help of the PDMS, e.g. during patient discharge and preparation of the discharge documentation. An increased number of process steps was found in the workflows "closing patient record" and "synchronizing PDMS data with HIS".

It is interesting to note that the largest reduction of process steps was found in the group "daily activities" (with three level 3 process steps eliminated). We saw a small respectively non existent reduction of process steps in the groups "admission" and "discharge/transfer".

Table 1 – rows 1-4: No. of workflows in the groups "patient admission"," daily activities" and "patient discharge / transfer" before and after PDMS implementation. Rows 5-6: Number of eliminated process steps in these workflows. Note that the total No. of workflows mentioned in the text (27) includes a top level linkage workflow which remained unaltered and is not considered here.

	Admission	Daily Activities	Discharge
1. Total No. of workflows	5	16	5
2. Workflows shorter with PDMS	2	13	3
3. No change in workflow length	2	2	1
4. Workflows longer with PDMS	1	1	1
5. Total No. of eliminated process steps	-1	16	0
6. No. of eliminated process steps level 3	1	3	0

This is in sharp contrast to the self estimation of nurses and physicians. Physicians reported no time savings at all whereas nurses reported considerable time savings during discharge activities which is not reflected in the actual workflows. Only the time savings in daily nursing documentation fit to a reduction of process steps in the respective workflows.

Discussion

Methods

Self assessment of time spent for documentation has been reported in other studies (see e.g. [18]). Compared to other available methods such as time motion studies, or workflow sampling its results are prone to subjective opinion, may reflect individual convenience and could be influenced by effects such as Hawthorne effect. In addition, predefined answering options may influence the results. Therefore we used intervals of equal length up to 50 minutes plus an option for precise numbers to minimize this effect.

Other time measurement methods require appropriate consent of the observed staff and enough observers to perform them. Another problem for exact time measurements is that we didn't know exactly what to measure before the second workflow analysis was finished. Thereafter a "before" measurement was no longer possible. Within the study we took some objective time measurements before and after system implementation, but the measured activities did not correspond well to the workflows. There are methodical limitations to measure e.g. the time spent for documenting for one patient one day or shift, because these are disruptive activities and clinical staff tends to combine documentation activities for several patients at a time.

We found only four studies dealing with workflow analysis in intensive care environment [11-14]. Just one study had a comparative approach [14]. Workflow analysis has gained impact in the area of hospital information systems and more specifically to improve workflows in radiology departments (see e.g. [18]). We are not aware of any study in ICU where workflow changes have been contrasted with time measurements or self assessment of time spent for activities. A potential problem of workflow modelling is the method used and the depth of process decomposition. We used a well described method for business workflow modelling [17] but nevertheless considerable degrees of freedom e.g. regarding depth of decomposition remain. Therefore it can be difficult to compare workflow models between institutions.

Results

Self estimations showed a reduction in nursing documentation time for daily activities and discharge whereas physicians did not report relevant time savings after PDMS implementation. This seems strange because the PDMS supports automated scoring of ICU patients and automated compiling of discharge summaries which otherwise consumes much time [20]. As a potential reason (apart from possible Hawthorne effect which should affect nurses and physicians likewise) we assume that fluctuation of medical staff, which was much higher than of nursing staff may have led to a situation where physicians at t2 and t3 had not been in contact with the previous paper based documentation. Altogether only 2 physicians completed all three questionnaires compared to 9 nurses. The majority of nurses had worked more than 4 years on this ICU, the majority of physicians less than 1 year. Both findings support this assumption. An objective time measurement should not be influenced by fluctuation, but self assessment of time spent for activities may well be dependent of the fact that the person noticed an improvement after PDMS implementation. Alternatively, the disjunct time intervals of self assessment (10 minutes) may have been longer than the potential time savings noticed by physicians.

We found a reduction of process steps in the "daily activities" workflows. Workflows during "admission" and "discharge" showed nearly the same total number of process steps before and after PDMS implementation. As mentioned previously, we expected improvements in those areas where data could be recorded once and then be reused. Typically, this would be the case e.g. in "daily" documentation of vital signs (automated data transfer from patient monitor), but also in activities around "discharge/transfer", where the PDMS helps to compile all previously recorded relevant information into one or several discharge documents. Obviously this is not reflected in a reduction of the total number of process steps. There, an analysis of time spent for "identical" process steps before and after system implementation would be conclusive. Again, the granularity of process steps (see methods discussion) may have influence not only on the total number of process steps but also on the differential count before and after PDMS implementation. Future work (the PDMS is in rollout to other ICUs as well) will concentrate on those findings and implement specific time measurements for such process steps.

Self assessment of time reduction reported by nurses did only partially correspond to a reduced number of process steps ("daily activities" group), but not in the "discharge" group. At this point a look into [14] is interesting. In this study dealing with a CPOE system the authors conclude that workflows in reality do not reflect workflow assumptions made during CPOE system design.

Methods such as direct time measurements or extensive work sampling studies to evaluate time savings after implementation of an information system have not always been conclusive [7,8]. In some cases time spent for indirect patient care tasks such as charting has been decreased, in others no change was found or even more time was required. Therefore we recommend to add the method of workflow analysis in order to pinpoint changes in workflow which can then be measured and validated much more specifically than before.

Conclusion

Considering our knowledge about change management and its influence upon success or failure of introduction of information systems it seems worthwhile to include pre/post workflow analysis into the toolbox for system evaluation in order to gain insight into the nature of inflicted changes. Results of this method can be used directly but will be even more valuable in conjunction with other evaluation methods such as time measurements, time estimates, subjectivist interview techniques, user satisfaction surveys etc. In addition, workflow analysis can play a formative role in system development and help to find weak spots in workflow. Its results may generate the base for an objectivist study which strives to deliver summative results. For comparison between different institutions it will be desirable to standardize the methods of workflow analysis and workflow modelling to achieve comparable workflow models.

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