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A KPI Framework for Process-based Benchmarking of Hospital Information Systems

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Abstract. Benchmarking is a major topic for monitoring, directing and elucidating the performance of hospital information systems (HIS). Current approaches neglect the outcome of the processes that are supported by the HIS and their contribution to the hospital's strategic goals. We suggest to benchmark HIS based on clinical documentation processes and their outcome. A framework consisting of a general process model and outcome criteria for clinical documentation processes is introduced.

Keywords. Benchmarking, hospital information systems, quality of information systems, process assessment

1. Introduction

Benchmarking of information systems has become an important method for strategic information management in hospitals. Camp defined it as "continuous process of measuring products, services and practices against the toughest competitors or those companies recognized as industry leaders" in order to find best practices [1]. Later the Joint Commission substituted "practices" as benchmarking subject by "processes" leading to the benchmarking aim of "improving products, services or processes" [2].

The board of the hospital and also the HIS users often lack in transparent information about the performance of the HIS. Especially the board regards the information system as a "black box" and can hardly estimate its contribution to a hospital's processes and strategic goals [3]. HIS benchmarking thus can serve as means for success control of HIS. However, appropriate key performance indicators (KPI) are needed for measuring and comparing different HIS. These KPI should be accepted by the board, the HIS users and the information management department.

From the board's and the HIS users' perspective, the quality of an information system is determined by supporting processes efficiently and by the information that is created, updated and used. We assume, if the HIS outcome in terms of information handled in the HIS is linked to HIS characteristics, benchmarking results can both help information management improving the HIS and help HIS stakeholders understanding HIS performance. In this paper we want to:

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1. analyze existing benchmarking initiatives and
2. develop a KPI framework for benchmarking HIS performance based on clinical documentation processes and their outcome for the HIS stakeholders.

2. Methods and Materials

2.1. Current Benchmarking Initiatives

Table 1 provides a limited selection of HIS benchmarking initiatives which considerably vary in their benchmarking subjects, KPI types and data collection methods.

Table 1. Information system benchmarking: benchmarking subjects, KPI types and data collection

Ref.	Benchmarking subject	KPI types (examples)	Method of data collection
[3]	information management processes	maturity models according to CobIT®: (0= process not existent to 5= process is managed)	CIO[2] survey
	IT cost, IT performance and IT support	IT cost per employee, IT users per IT staff, clients per bed	CIO survey
	clinical processes and their IT support (e. g. order entry)	self-defined maturity models	routine data from application systems
[4]	information handled with HIS (discharge letters, appointments)	completeness and timeliness of discharge letters, number of electronically scheduled appointments	routine data from application systems
[5]	EMR system	system quality, information quality, service quality, use, user satisfaction form together a "composite index"	user survey (CIO, CMO, CNO[3], doctors, nurses)
[6]	application systems making up the electronic medical record	maturity model (stage 0 to 7) based on evolutionary development of information systems in U.S. hospitals	CIO survey

There is no common agreement on the subject of HIS benchmarking: Should application systems, clinical processes, IT cost or information management processes be benchmarked (see 2nd column of Table 1)? Regarding the KPIs (3rd column of Table 1), the following advantages and disadvantages with respect to stakeholder expectations and practicability for information management occur.

- Using a maturity model or a composite index ([3], [5], [6]) finally results in a number on an ordinal scale which is useful to compare a large number of HIS. However, if, e.g., the board cannot relate the scales to the hospital's processes or strategic goals, the KPI run the risk of being not accepted.
- Cost-related KPI like "IT cost per employee" [3] do not describe how well the HIS works and how it contributes to the hospitals' business goals.
- Measuring the outcome of clinical documentation processes [4] seems plausible for stakeholders. However, the outcome needs to be related to the HIS.

Regarding data collection, the least time-consuming method is to conduct a survey among CIOs (4th column of Table 1). However, there is a risk of gaining biased results from an information management perspective. User surveys help to get a more comprehensive view of the HIS performance. Collecting and analyzing clinical routine data is an objective and cost-saving method to gain KPI.

[2] CIO = chief information officer

[3] CMO= chief medical officer, CNO = chief nursing officer

2.2. The General Documentation Process Model and KPI Based on Process Outcome

The benchmarking approaches introduced in 2.1 are useful to rank and categorize HIS as a whole. However, to focus on the "asset" information itself and the problems with creating, updating or using information with help of the HIS, we deal with documentation processes as benchmarking subject.

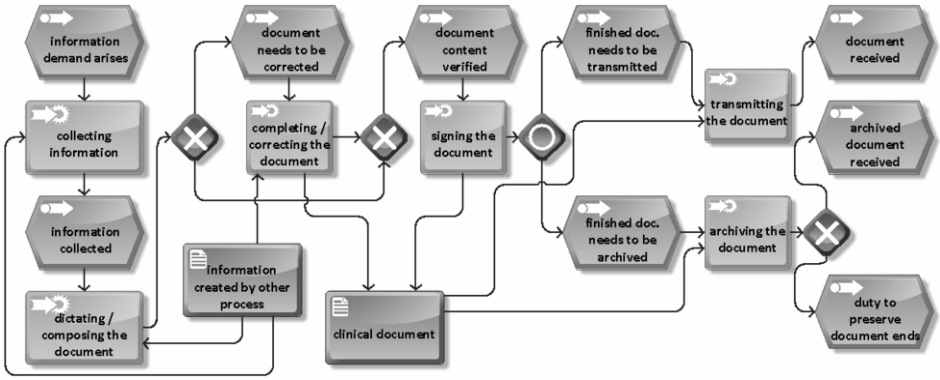

Figure 1. General model of a documentation process. Hexagons denote events, rectangles with white arrow denote activities, rectangles with document icon denote documents, "X" stands for logical XOR operator, "O" for logical OR operator. (Tool: ARIS express, www.ariscommunity.com)

First, we created a general model describing documentation processes and the lifecycle of clinical documents. We used the results of projects at the University Medical Center of Leipzig, in which discharge letter writing, order entry and result reporting were analyzed. For modeling we used event-driven process chains (EPC) [7] and their concepts "event", "function" and "information object" as well as logical connectors (see Figure 1; model elements will be referred in the text using italics). For example, the start event *information demand arises* may represent "patient is discharged from hospital" or "lab examination ordered". The process functions, e. g. process steps of *collecting information*, *composing*, *correcting*, *signing*, *transmitting* and *archiving the document* can be supported by IT to different degrees. The process ends when the user of the final document has *received* it. Second, we searched for KPI categories which are from different stakeholder perspectives useful for assessing the outcome of documentation processes. They are related to the *clinical document* after *signing the document*. Another premise was to identify objectively measurable criteria.

We decided to adopt six outcome-oriented categories from the HIS monitor by [8] to our framework, but to measure them not only by a user survey (us) but also by means of routine data (rd) from application systems. In a Delphi survey [9] top 15 KPI were identified, which CIOs and HIS researchers consider to be important for benchmarking of HIS. These KPI were also considered for our framework as far as they can be measured for processes. We added generalized criteria defined by [4] to our list of outcome criteria:

- **O1**: timeliness of the clinical document [4] (rd/us)
- **O2**: availability of finished clinical document (in hospital) [4], [8], [9] (rd/us)
- **O3**: time needed for information processing [8] (rd/us)
- **O4**: user satisfaction with documentation process [9] (us)
- **O5**: completeness/correctness of finished clinical document [8] (rd/us)

- **O6**: compliance of the finished document with legal regulations [8] (rd)
- **O7**: usability of the finished document [8] (rd/us)
- **O8**: readability of the finished document [8] (us)

Now these outcome criteria need to be explained by subcriteria for the process flow (P) and the underlying structures (S). For example, O1 and O3 immediately depend on the duration of process steps such as *collecting information* or *completing/correcting the document*. I. e. the duration of these steps can be chosen as subcriterion for O1 and O3. Similarly, O4 can be further divided into "user satisfaction with single process steps". In a next step, structural criteria explain the process outcome. In terms of the HIS, the underlying (types of) application systems for the process systems should be taken as a criterion. However, it is also necessary to consider not only technology facts, but also organizational facts and human facts [10], e.g. the education background of personal resources involved in the documentation process.

3. Results

Table 2. Examples for key performance indicators for discharge letter writing, "rd" marks KPI to be gathered from routine data, "us" marks KPI to be gathered by a user survey

Process outcome	Process flow	Underlying structures
O1: timeliness of discharge letters (rd)	time for single process steps (doctors and clerks separately) (rd)	S1: type of application system used (rd), organization: department
O4: user satisfaction with process of discharge letter writing (us)	user satisfaction with IT support of single process steps (us)	S1 (us), users' professional grade (us), organization: central or decentral clerks (us)
O6: legal relevance of electronically stored discharge letters in terms of use of electronic signatures (rd)	-	application system used for signing (rd), organization: department

The KPI framework for benchmarking HIS consists of our general model for documentation processes and outcome criteria related to the process flow and underlying structures (see 2.2). Based on existing benchmarking methods (2.1), we recommend a mix of data collection methods. For using the framework follow the steps below:

- Decide on the process to be improved and the benchmarking partner(s).
- Map the general documentation process model to the process to be observed.
- **Outcome**: Choose relevant KPIs from O1 to O8. For time-related criteria use the events of a documentation process as measuring points.
- **Process flow**: Refine outcome criteria by looking at the single process steps.
- Consider the underlying **structures**, which may affect the outcome (information system, human factors, organizational factors)**.**
- Choose data collection methods (routine data vs. standardized user survey).

In a joint HIS benchmarking project between Leipzig Medical Center and Hannover Medical School we used the framework to define KPI for the process of discharge letter writing. We concentrate on the criteria O1-O6. For example, the timeliness of discharge letters (O1) we defined as the duration between the events *information demand arises* and *finished document needs to be transmitted*. Related process criteria are times for *dictating* and *correcting* the document. As structural criteria, the type of application system (e.g. normal text processing system, digital dictation system) and the department are to be determined (see Table 2 for some examples).

O1, O5 and O6 and their subcriteria are determined by using routine data from the clinical information systems. O2, O3 and O4 are subject of a user survey among physicians. The user survey was implemented in LimeSurvey® and is currently running. In a pre-study, interesting results could be obtained. E. g., physicians often spend half of their working days with writing discharge letters what emphasizes the need for finding best practices for the IT support of this documentation process.

4. Discussion

KPI and their critical reflection have to be integrated into a continuous strategic information management process, e.g. by a strategic information management board. After the first benchmarked processes have been improved sufficiently, more processes have to be included. Meanwhile, KPIs of well managed processes can be reduced.

From a methodological perspective, new or extended process modeling languages are necessary, which support the mapping of processes with quality measures [11].

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