A three-step methodology for process-oriented performance: How to enhance automated data collection in healthcare

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Abstract

Background. Healthcare managers often attempt to enhance process-oriented performance. However, this remains a challenge. New approaches aimed at increasing the implementation success of process-oriented performance measurement should be investigated.

Methods. This study investigates and discusses a step-by-step methodology to implement an automated and effective process-oriented performance measurement system in a hospital. The methodology is based on a framework for developing dashboards based on three steps: the demand side, supply side, and the fit between the two. An illustrative case of the process of hip surgery in the operating room of two hospitals is used.

Results. A methodology is developed to define a reliable set of process-oriented performance metrics, allowing analysis and management of the different flows in healthcare in an integrated way, and by investigating several methods to automatically integrate the data gathered into a reporting infrastructure than can be used to disseminate the results.

Conclusion. This step-by-step methodology allows healthcare organizations to develop and implement effective process-oriented performance measurement in an automated way. This allows the alignment of the goals of hospital management and various stakeholders with the more analytical analysis of business process management notation and hospital information system data.

Background

In the last decade, hospitals have tried to move from functional to more process-oriented organizational forms [1]. The process orientation of organizations results in improvements in process flow, quality, costs, financial performance, and customer satisfaction [2]. To simultaneously increase the efficiency and quality of their operations, hospitals are investing in process management and process optimization [3]. However, there is still an absence of clear process thinking in many hospitals, as well as a lack of knowledge about how to identify and monitor these processes using performance indicators [4].

Following Porter et al. [5], two main types of processes can be identified in hospitals. First, there is the actual "treatment", with the aim of caring for or curing patients; this includes all medical and clinical activities related to diagnosis, therapy, surgery, and other care. The treatment process is the primary flow and shapes the patient flow. Second, there are "supporting" processes to reinforce the "treatment", including all nontreatment processes, like logistic flow and information flow. These flows use different resources, like staff, equipment, and materials. Process-orientation within a hospital assumes an integrated view of logistical, information, and patient flows [6]. Current processes in healthcare must be modified to better coordinate, align, and synchronize different flows and resources (e.g., staff, equipment, and materials). Ultimately, this should result in a more efficient patient-centric workflow [7]. The current tendency towards accreditation and certification in the healthcare sector endorses this need and reinforces process management [8].

There are some challenges in developing process-oriented performance measurement systems in hospitals. First, most performance measures in hospitals are not process-oriented [4] and cannot assist healthcare systems to synchronize patient, logistical, and information flows.

Second, different stakeholders have an impact on the performance of different flows in the system [9], resulting in a variety of potential performance indicators. Having a reliable method to define performance metrics that can monitor and steer different healthcare flows is therefore an important challenge. Third, more and more data is available in hospitals [10]. The integration of large amounts of raw healthcare data across several dimensions remains a huge challenge [11]. As the interoperability of systems and data storage is still insufficient [12], it is a challenge to capture and organize data to support and improve decision-making. This creates opportunities to develop process-oriented performance measures based on existing databases. Data can thus be collected in an automated way, making implementation of process-oriented performance management systems more feasible.

In this study, we overcome these challenges by proposing a step-by-step methodology for defining a reliable set of process-oriented performance metrics, allowing analysis and management of the different flows in healthcare in an integrated way, and by investigating several methods of automatically integrating data into a reporting infrastructure for dissemination, permitting implementation of process-oriented performance measurement in hospitals. This will help hospital managers to achieve a process orientation while integrating patient, logistical, and information flows.

The three-step methodology

Organizations are dealing with an increasing amount of data. It is a therefore a challenge to capture and organize these data to support and improve decision-making. The problem of information overload can be managed using interactive visual information displays to support decision-making by implementing key performance indicators (KPIs) in a dashboard [15]. KPIs are “quantifiable metrics which reflect the performance of an organization in achieving its goals and objectives” [16]. A dashboard brings the organization’s KPIs into a single display and aims

to visualize them in order to increase understanding of performance [17]. Commonly, only a relatively small number of interconnected key performance metrics and underlying performance drivers reflect both short-term and long-term goals throughout the organization [18].

We employ the conceptual framework of Pauwels et al. [19] to develop a dashboard for hip surgery patients in the operating room (OR) of the two hospitals. Pauwels et al. [19] discuss the importance of the relationship between the demand and the supply side of dashboards. Our methodology (Fig. 1) develops practical steps to investigate the demand and supply sides and provides a method for fitting the two.

Insert fig. 1 about here

Figure 1. A step-by-step methodology for developing a dashboard

Step one: the demand side of the dashboard

In the first step, we investigate and visualize the demand side of the dashboard. The demand side represents the users of the dashboard, including hospital senior management as well as process owners and participants, such as coordinating physicians, department heads, head nurses, physicians, and nurses [20]. It is crucial that managers consider the opinion of these different stakeholders in developing KPIs for the demand side [19, 21]. Different professional groups have their own incentives, and conflicts among these groups can result in the continuation of suboptimal systems. To avoid suboptimal systems, vertical alignment and horizontal integration are aimed for. Vertical alignment means that the key performance metrics must reflect the vision and strategic goals of the hospital [20]. Second, activities across organizational units should be visualized by measuring the performance and interplay of the upstream process of the patient with the downstream supporting processes—i.e., horizontal

integration [22].

Step two: The supply side of the dashboard

It is important to link the process-oriented data from information systems to the KPIs using a bottom-up approach. Process-orientation in hospitals implies that we know how processes are operated in the organization and what process data is available [19, 28]. In our framework, this is represented by the supply side. To obtain this goal, we explored the processes in the OR for the total hip replacement procedure. A detailed business process management study was performed on patient flow and the various supporting logistics and information flows in each hospital.

Step three: Fit between demand and supply side

The fit between demand and supply is critical for successfully implementing dashboards [30, 31]. The type of information provided should match with the decision responsibilities for various users and the metrics in the dashboard should be those that are crucial for hospital management goals (demand side). There are still many technical challenges and difficulties in integrating dashboards with legacy systems and the applications that feed data into them [10].

Methods

This study's objective is to develop and investigate a step-by-step methodology for implementing a process-oriented performance measurement system in hospitals. We use an illustrative case study [13] from the operating room (OR), which is a key hospital resource, as 60%–70% of all hospital admissions are induced by pathologies requiring surgical intervention [14]. Denton et al. [14] state that the OR is the largest cost center and greatest source of revenue for most hospitals. The study was conducted in two hospitals: the first has 822 beds, 2300

employees, and 220 physicians; the second has 554 beds, 1600 employees, and 170 physicians. The study was approved by the medical ethics committees at the hospitals and at the University Hospital of Brussels. All participants gave informed consent for participation in the research. As the study aims to develop a step-by-step methodology, data collection was conducted in three different steps using diverse methods.

Data collection

Data collection for the demand side

To collect data for the demand side a qualitative study was carried out. First, a systematic literature review was performed to develop a list of indicators for the structured interviews. To do this, we updated the results of the systematic review of Liu [23], who analyzed KPIs in articles published to 2012 in PubMed and PubMed Central. Liu [23] compiled a list of 66 indicators.

We applied the same selection criteria and searched PubMed from June 2012 to April 2014. Since the focus of this study is the operation room and the hip surgery process, we also included the following terms: "THP or total hip replacement or hip arthroplasty or hip surgery" and "Operating room or Operation room or OR". Based on the results of our systematic review, seventy-two additional indicators were added. Thereafter, the list was revised by two experts and a pilot interview was carried out with a surgeon. The resulting list contained 138 KPIs.

Second, participants were selected by contacting representatives of the hospital management. Sixteen qualitative semi-structured interviews were executed. Yigitbasioglu and Velcu [10] argue that KPIs should be developed and monitored at different levels in the hospital, depending on the goal and needs of specific users. We hence incorporated the views of different users and actors from the multiple disciplines (Table 1) involved in hip surgery cases at the two hospitals.

Table 1. Overview of the interviewees

Insert table 1 about here

The interview contained two phases:

Part 1: Semi-structured interview. Questions were asked about which performance indicators were measured in the hospital and the usefulness and importance of these indicators—for example, "Which performance indicators are already measured in your organization?"

Part 2: Structured interview. This part was performed by presenting KPIs to the interviewees on cards. The structured part of the interview was fed with a list of 138 KPIs based on the extensive literature review and consisted of three steps:

First, participants were asked to select all the indicators they thought important to monitor; they were asked to explain why they found these KPIs important. Next, they were requested to select the 20 KPIs that they perceived to be most important to measure and follow up on. Finally, they were given the task of reducing the list to 10 KPIs.

The recorded interviews were transcribed verbatim and analyzed using NVivo 10. The data were content-analyzed for emergent themes using the framework approach of Ritchie and Lewis [24]. We used the content of the interviews and of the three rounds of selection of the KPIs to decide which KPIs should be integrated in the dashboard. The ranking was performed across all interviews. First, we added the number of times a KPI was selected by the participants in each round. Second, we wanted to allocate more value to the final two rounds, considering that participants had to eliminate KPIs in the second and third round. Hence, we multiplied the number of times a KPI was selected by three for the third round, and by two for the second round. We then added up these scores to get an overall mark per KPI. Next, we ranked the KPIs top down and drew up a comparison between the two hospitals. An overall list was thus developed. Considering that the number of indicators monitored by a dashboard needed to be

manageable, we decided to retain 20 KPIs in the overall list. This is comparable with the healthcare literature, where the number of KPIs ranges from 10 to 30.

Liu and Itoh [25] created a list of 27 outcomes, and 24 KPIs were measured in the research of Harris et al. [26]. However, Shohet [27] used only 11 KPIs.

Data collection for the supply side.

To analyze the patient flow, we based the exploration of the process on a document analysis focused on existing standards in healthcare: the clinical pathway. Thereafter, three interviews were carried out; two nurses and one nurse practitioner were questioned. Several process steps were explored and, at each step, interviewees were asked which tasks needed to be performed to move to the next step.

Twenty-one group interviews were organized at each hospital to outline the supporting flows. The interviewees were employees carrying out surgery or managing resources (such as skills, equipment, and material). The exploration of logistic flows was based on the bifurcation of different types of critical resources identified. The logistic flows can be decomposed using a decomposition list—a check-list of subprocesses that are "common" in most industries. Several questions were asked, like "Which activities are executed in these subprocesses? When and how are these activities executed? How frequent are these activities executed?" For each resource type, a decomposition list was filled out in a textual manner. The decomposition list also allowed identification of information flows.

The alignment of the different processes was then investigated. To identify the level of integration for supporting flows (logistics and information) and the patient flow, we linked the upstream patient flow with supporting logistic flows by determining whether the patient flow is steered by the supporting flows. The next step evaluated which data were already available

in the hospital information system (HIS) to measure the performance of the process-oriented KPIs identified in the demand-side analysis. Data and databases were investigated on the basis of results from the interviews, observations, and document analysis. An information technology (IT) expert was also consulted to explore the interoperability of the systems, though this could be an IT expert from the hospital.

Data collection for the fit between demand and supply side.

A focus group of several experts was organized to discuss which data and processes could be linked to KPIs. The focus group contained an IT specialist from the industry, three IT researchers, one researcher and one professor in healthcare operations management, one hospital manager and one PhD in logistics management. The goal of the focus group was to bring the demand and supply sides of the framework together.

Results

Demand-side

The results of the demand-side show discrepancies in the perspectives of the two hospitals. Depending on the different strategic and tactical goals within hospitals, participants selected different indicators and proposed different rankings. Table 2 presents the 29 KPIs chosen by either hospital 1 or hospital 2. Hospital 1 tended to focus more on costs and efficiency, while hospital 2 had more clinical outcomes in their top ten KPIs. Less than 50% of the indicators selected by hospital 2 were also in the ranking of the twenty most important indicators for hospital 1.

Table 2: Ranking and comparison of the most important KPIs for each hospital

Insert table 2 about here

Using a qualitative research design enabled the researchers to gain a more in-depth view into the reasons for the selection of the KPIs. This enhanced the ranking of KPIs. There are not only differences between hospitals; differences also exist between professional groups. Physicians, head nurses, and the medical OR managers tended to focus dominantly on the patient perspective, contrary to administrative and nursing OR management, who focused more on efficiency. Our analysis shows that participants selected indicators that measure supporting processes, as well as treatment processes.

Since there is a difference between these hospitals in the selection and ranking of KPIs, this study suggests that each organization should investigate which KPIs are to be included in the dashboard, depending on the goals of the hospital and stakeholders. Moreover, since different stakeholders within the organization prioritize different KPIs, hospital managers should include the perspectives of different stakeholders and use a methodology, such as that is described in the previous section, to find a consensus.

Supply side

To collect data for the supply side, the patient flow and various supporting logistics and information flows were mapped.

Describe the patient flow.

In a first step, we examined the treatment process that shapes patient flow (Fig. 2). The flow of a patient undergoing total hip replacement is determined mainly by the clinical pathway. Clinical pathways are tools for guiding evidence-based healthcare [29]. Gathering data from clinical standards gives insight into several procedures and registration policies in the patient process, like surgical safety checklists, pain protocols, and preoperative interventions. The flow can have various statuses: A patient passes through different statuses during the entire treatment

process. Several tasks should be performed before the patient can move to the next status. For example, before gaining the "admission" status, the patient should be informed and examined. This status involves several necessary tasks. First, patients receive information from the surgeon, anesthesiologist, physiologist, and social service worker. Second, a preanesthesia investigation is performed: X-ray, ECG, screening of nosocomial infection, and a blood test. Third, an informed consent form and an information brochure are distributed.

Insert fig. 2 about here

Figure 2. The patient process

Identify and describe logistic and information flows.

We identified thirteen different logistic flows for the delivery of materials from supplier to the OR (Table 3). Other important resources were found to be the nurses, head nurses, and physicians. The OR and sterilized equipment were identified as critical equipment for surgery.

Table 3. Product categories of logistic flows

Insert table 3 about here

The unregistered sterile material process is discussed as an example (Fig. 3). First, the logistic flow is described. The supplier delivers unregistered sterile material to an external company's central distribution point. From there, these are delivered to the OR by different types of processes. Some of these materials are stored in the ORs, others are stored on other locations i.e. storage location outside the OR. The replenishment of these storage locations is based on various information flows. A min–max SAP warehousing management system

replenishes the platform. The storage location outside the OR is replenished using a Kanban system (empty bins are scanned) [41] and replenishment of the ORs is based on handwritten order lists.

Insert fig. 3 about here

Fig. 3 Logistical process of the non-registered sterile products

This also occurs in the twelve other logistic flows. A different number of logistics and information flows exist to supply the OR. For example, sometimes the supplier delivers directly to the OR, as with infusion therapy, prosthesis in consignation and borrowed prosthesis, stitching materials, nonstorage materials, and sterile products (custom packs). General medication, opiates, and registered sterile products go through the pharmacy and the external platform is used as an intermediate storage for sterile unregistered materials and disposables. Automated data collection for supplies, consumption, and storage is limited to two programs in the hospital (Infohos and SAP). SAP is used for processes that pass through the external platform and for the stitching-material and sterile-product (custom-pack) processes. The Infohos database is used when intermediate storage is at the pharmacy. Replenishing the pharmacy and external platform is managed using data on consumed materials and the stock levels. However, SAP can only register processes and costs before products leave the intermediate storage. Replenishment of medication is based on the number of consumed products registered in Infohos. Consumed medication is registered by hand in Infohos directly or in a paper file. The interoperability of these systems remains insufficient. These examples illustrate that supporting flows (information and logistics) in OR are very complex and costly processes that remain unaligned.

Level of integration of supporting and patient flows.

There are only two logistic flows driven by the patient process: OR planning and prosthesis ordering (Fig. 2). Three moments of interaction occur: when the decision is made that surgery is necessary, after informing and examining the patient, and at the moment of surgery. First, the decision to perform surgery is made: the two resources (prosthesis and OR) are released and confirmed. The information flow between the supporting and the patient processes is very important for these two resource types; however, it is neither followed-up nor automated. No other logistic flows are driven by the patient process. The first and only link for the other logistic flows was at the moment of interaction, at the moment resources were released in the preoperative phase. This means that the planning of logistic flows is not linked to patient flow, which should be the "trigger" for these processes. This methodology shows that both the supporting flows and the patient flow should be evaluated to obtain an overall view of the processes, as integration of flows is limited. By automating data collection and enhancing information flow, the alignment of the different flows can be improved.

Evaluate available data.

The following step evaluated which data were already available in HIS for measuring the performance of the process-oriented KPIs identified in the demand-side analysis. Much patient flow data had already been gathered, like data in patient files, data on clinical pathways, data from the OR planning tool. Generally, data collection was required for clinical reasons and some was done by hand. Employees were not always informed of the goals of data collection, which made it more complicated for them to collect and register the data correctly. Furthermore, most of the data collected in the hospital was not process-oriented and even when there was process data available in the HIS, it was hard to use the data since it was not saved in a structured way.

Logistical information was also available (e.g., SAP, Infohos), but there was no integration with patient flow data, and most information was still not connected to the hospital-wide information system. The evaluation of the available data shows that much information on supporting flows is scattered over various IT systems and software. Moreover, many procedures in healthcare are still registered on paper—e.g., pain procedures, surgical safety checklists, preoperative checks.

The fit between demand and supply side: Integration of KPIs in the dashboard

Automated data collection in dashboards improves compliance with best practices and evidence-based medicine and management [32]. Hence, the goal in this phase was to find a method to enhance automated data collection for process-oriented indicators. Existing techniques and procedures should be adopted to integrate process-oriented data into the dashboard. Two different approaches for such integration can be identified.

A first approach is to feed real-time generated data directly into a dashboard. Some KPIs are registered in the HIS and may be linked directly to the dashboard. These are often KPIs that the government requires reports on. Examples include incidence of decubitus, number of readmissions, nosocomial infections, and number of hospitalization days. There are also many KPIs indicated as important by the interviewees which do not need to be reported: number of surgeries performed by a surgeon, duration of surgery per physician, occupancy of the orthopedic department and OR, and sickness absence. Currently, all this data is available in the HIS; however, it is not available in a structured way. Most indicators are followed up on a hospital or department level and are not linked to specific clinical procedures or supporting processes. Consequently, it is hard to track down problems and follow up the performance of treatment processes. Making data more visual on a process level, as illustrated by our methodology, will result in the easier follow-up of process data and will improve outcomes.

The second approach is to use a business-process management notation application (BPMN) combined with data from the HIS. To our knowledge, this is a new approach to integrating process-oriented performance indicators into healthcare measurement systems. Several process-oriented KPIs, such as the surgical safety checklist, performance evaluation of employees, pain management, correct bills of materials, and correct preoperative screening consist of small tasks that must be performed in the correct order, in the legitimate way, and at the proper moment. Current procedures in hospitals are registered in paper files. The focus group suggested a new approach of importing these data into the HIS. BPMN should be applied to outline these process-oriented KPIs. Thereafter, the new process information allows the representation of clinical procedures or supporting process by KPIs in the dashboard. The surgical safety checklist is a checklist of a procedure that contains several steps that need to be executed before starting the surgery. At the moment this is a list that is filled out by hand. This process could however be simplified by using the HIS. First, each task in the process is delineated and implemented in the HIS using BPMN. Second, important real-time and process data reflecting the quality of data registration is linked to the KPIs.. A BPMN-task can or should be performed per step. Second, several quality indicators can be coupled to the process—like verification (Has the list been checked by somebody else?), completeness (Have all tasks been performed? Has every question on the form been filled out?), and consistency (Are there mistakes in the form?). All this performance information is reflected in one KPI, the surgical safety checklist. However, using the drill-down capabilities of the dashboard, a manager can trace certain underlying irregularities. Drilling down helps to explore the details of a selected KPI to track down problems in a process [33]. Another advantage of this approach is that the tasks—in this case, to answer questions—can be made mandatory. If the surgical safety checklist is coupled to the IT-system in the OR, users can be obliged to fill in certain forms before the next screen is presented. This approach increases the reliability and response rate of

the surgical safety checklist, leading to fewer mistakes and improved quality of care. Since standardized procedures following evidence-based guidelines like the surgical safety checklist and preoperative procedures are gaining importance in healthcare quality measurement, this solution will assist professionals in executing these guidelines. The direct and indirect costs of surgery and materials can also be outlined using this approach by coupling costs to the different tasks performed in the BPMN tool. Hence, the process cost of each step in the process can be taken into account.

An additional function of the dashboard is simulation [34]. Simulation methods make it possible to explore whether process changes will result in a return on investment. The BPMN-tool can be applied to design a possible process change. Using simulated data, the impact of the hypothetical process changes can be investigated by analyzing process-oriented KPIs such as waiting time before surgery, duration of surgery, and the occupancy of an OR. Bottlenecks can be tracked down [35] and problems can be discovered and predicted. Consequently, the dashboard becomes a very interesting working tool for the hospital. We can conclude that different approaches should be applied to incorporate KPIs into dashboards.

Discussion

As hospitals attempt to shift from functional to process-oriented organizational forms, process-oriented performance measurement systems gain importance. This paper contributes to the development of a methodology to improve process-oriented performance measurement using an illustrative case study of hip surgery in the ORs of two hospitals. The methodology (Fig. 1) enhances process-oriented performance measurement in healthcare.

First, important KPIs were identified. Different stakeholders were investigated to obtain a consensus on views on performance, studying measures of patient and supporting flows. Our

analysis shows that participants selected indicators that measure both supporting and patient flows. Discrepancies were shown between the two hospitals and different disciplines. These results are in line with those of Cardinaels and Soderstrom [36], who state that each stakeholder uses a set of diverse criteria and standards to evaluate the legitimacy of the organization [37]. This methodology enables healthcare managers to focus on measurements and goals that are important for their hospital.

Second, processes were described and studied to link process-oriented data from information systems to KPIs using a bottom-up approach. This step provides in-depth information on existing processes and process data available within the healthcare setting. We found that most supporting flows were not steered by the patient flow, although poor patient flow management is related to a series of problems that are typically related to support flows, like supply shortages, resource waste, and low productivity level [38]. Mapping the different flows through the hospital gives an in-depth process view and creates possibilities of more process-oriented data collection.

Third, the available data and possible approaches were investigated to integrate data from the HIS into the dashboard. This is crucial for the alignment of the demand side with the supply side. In this paper, we outlined different approaches. Besides the more straightforward approach of feeding HIS data into the dashboard, we proposed the use of BPMN as a new approach in a healthcare setting to integrate data into the dashboard. On top of this, we showed the importance of simulation. Using BPMN has several advantages [39]: we were able to link overall business goals with the objectives for each task, process, and subprocess. Automated data-collection using BPMN increases the advantages of implementing a process-oriented dashboard in a hospital setting. However, qualitative data like perceived satisfaction are difficult to incorporate into dashboards. Analyzing the unstructured qualitative data using computational techniques (e.g., natural language processing to extract medical concepts from free-text documents)

permits finer automated data acquisition. Future research should investigate how to incorporate qualitative data [40].

Limitations

Although this methodology improves the development and implementation of a comprehensive process-oriented performance measurement system taking into account patient, logistic, and information flows, it still has some shortcomings. KPIs related to the perception-based measurement of performance, like satisfaction (e.g. employee satisfaction, patient satisfaction, and PROMs), were considered by the focus group as important to include in a dashboard. However, we did not find a method to do this in an automated way. IT implementation is not problematic, but the methodology to gather this kind of information is.

Another limitation of the study is that the methodology has been only partly tested. An overall real-time dashboard has not yet been implemented in a hospital setting. However, the methodology has been implemented and partially tested. First, a demonstrator was developed for the project. Second, an IT-integrator implemented the BPMN-procedure for filling in the surgical safety checklist. Third, the alignment between patient flow and supporting flows was optimized for the blood transfusion process at the ER using this methodology, but no dashboard was developed.

Conclusion

The major contributions of the proposed methodology are the facts that the goals of hospital management and various stakeholders are linked to the more analytical BPMN and HIS data, and that our three-step methodology enhances process-oriented performance measurement and management. The integration and visualization of the hospital goals with the HIS and process

data enables hospital managers to implement process-oriented performance measurement. In this way, this work contributes to hospital managers' quest for more process-oriented decision-making.

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