

Information Need and IT demands for Business Process Reengineering in Operation Room Management

Anja Zoeller¹, Christof Denz², Andre Baumgart³, Hans-Joachim Bender²,
Essameddin Badreddin³, Armin Heinzl¹

¹Department of Business Administration and Information Systems
University of Mannheim
Schloss
D-68131 Mannheim / Germany
zoeller@bwl.uni-mannheim.de
heinzl@uni-mannheim.de

² Department of Anaesthesiology and Critical Care Medicine
University hospital Mannheim
Theodor-Kutzer-Ufer 1-3
D-68167 Mannheim / Germany
christof.denz@anaes.ma.uni-heidelberg.de
hans-joachim.bender@anaes.ma.uni-heidelberg.de

³ Automation Laboratory
University Mannheim
B6, 23
D-68131 Mannheim / Germany
andre.baumgart@ti.uni-mannheim.de
badreddin@ti.uni-mannheim.de

Abstract: As the economic importance of operation room (OR) management is increasing, the aim of this paper is to analyse the information need for business process reengineering (BPR) in OR management and to reveal the need for corresponding IT support. The information on OR processes available in clinical standard documentation schemes proves fragmentary and insufficient for the needs of process analysis in BPR. Therefore a precise, detailed OR process model is analysed on relevant process interdependencies and influencing variables to reveal the crucial information need for OR management. The analysis includes empiric data, collected in a field study and shall form the basis for developing an adequately comprehensive documentation scheme. Its purpose is to uncover and pin-point where the need for information and respective IT support lead to an improvement of BPR for OR management.

1 Introduction

1.1 Importance of OR management

The regulatory environment for hospitals in Germany has been redesigned towards a more economic view for many years now. Especially the introduction of the DRG (diagnosis related groups), a performance-based reimbursement system supports the increase of case numbers with a simultaneous reduction of the hospital residence time. The aim of the DRG-system is to initiate competition between the hospitals and to activate economic reserves for more efficient procedures. This performance-based reimbursement system honours procedures which improve hospital specific services (i.e. surgeries as a value adding procedure). Thus it reduces long hospital stay times and delayed hospital discharge [CL00, ALS00, LL00]. In the past a high occupation of available bedding capacities was the main focus of utilisation planning, while the management of OR areas was determined by temporal and organisational peculiarities of different operative disciplines. Under the new economic conditions the reorganisation of hospitals will focus on the complete OR area as a central service unit with the most intense demand on human, spatial and temporal capabilities in the hospital. Due to high-quality technical equipment and very high staff numbers in the OR area the surgical care causes more than 30% of the overall treatment costs for an in-patient stay [Ma+95, SSB03].

To ensure an optimal resource allocation and efficient processes flowing the overall hospital strategy, numerous authors call for the introduction of a professional OR management [Be03, Ge+02, BCA02, Re+03, Ge+03, Ri02]. OR processes are characterized by complex, interdisciplinary processes spanning different professional groups. They show numerous process interfaces that increase process vulnerability and therefore endanger the productivity of this core medical unit. Concurrently the surgical care of a patient is the central component of the surgical therapy and is considered to be the key part of the clinical value-added chain [Ge+03, ST99]. Thus the central tasks of a professional OR management are the analysis of relevant workflows in the OR area as well as the control of human, spatial and temporal resources. When equipped with clearly defined competences and full instruction authorities for all employees working in the OR area, the OR management has the potential to design the whole perioperative workflow. This also refers to improvement potentials at the interfaces to adjacent units.

1.2 Challenges of OR management

Although the requirements for an efficient OR management are well formulated, there are only few investigations reporting on the implementation of hospital OR management [Bu04, Zö+06]. According to these an OR management exists in approximately 60% of all hospitals, whereby the structural organisation of the OR areas is picked out as a central theme, first. The obligatory introduction of an OR management statute is part of it, regulating the organisational competences of the OR management for all employees involved. Furthermore the hierarchic position of the OR management - with a direct assignment to the clinic management - shows the importance of the OR area for the entire hospital.

Our own study [Zö+06] shows the benefit of OR management for large OR areas, as a result of OR statutes defining organisational structures and respective authorities. However, it also indicates that a serious potential in improving process orientation in OR management is still remaining. This especially concerns the aspects of planning and coordination of interdependent and adjacent OR processes, including the consideration of dynamic aspects such as disturbances and emergencies. Compared to the postulated importance of OR management there is a need for further advancement. This concerns research on the provision of necessary information as well as the efficient use of available information in planning and control of the daily OR business.

In recent medical literature, surgery unit management is treated mainly from an organisational point of view. For example [SSB03, Be03, Ge+02] give guidelines for an adequate organisation structure, describe a central OR management and discuss where to best settle the respective organisational authority. This provides a basic framework for the organisational structure to enable the improvement of OR management, but it requires further development, supporting process orientation and the operational structure of OR management. Concerning process orientation, traditionally simulation studies have been applied [KKS76, LD99, BDH02, De05] to examine one-time changes in OR processes. For certain surgery unit layouts, they offer advice on scheduling policies or predictions on demand for personnel and rooms. However, they neglect realtime control approaches supporting daily OR management and do not discuss the respective information need on critical process interfaces and influencing variables. Therefore, the aim of this paper is to analyse the information need on critical and vulnerable OR processes and to show the need for corresponding IT support in OR management.

The remainder of the paper is structured as follows. In the next section the information on OR processes available in clinical standard documentation schemes is evaluated. Based on these process-mappings areas are highlighted that have to be refined for the needs of process analysis. The third section provides an analysis of a detailed, high-resolution model of interdependent OR process flows - including respective data collected in a field study. This analysis reveals crucial information needs for OR management as well as the demand for respective IT support and develops opportunities to enhance OR management. Finally, we summarise our findings and offer an outlook on future research activities.

2 Process identification and modelling

2.1 Modelling OR Processes

An initial OR process model was extracted from standardized documentation schemes [OW02, BCA02]. These time-recording schemes provide information on basic activities and include core times like transection times, suture times or a general surgical attendance time. However, these documentation schemes exist for different professional groups in parallel and do not match in extent and definition of relevant process times. Moreover they lack information on subtasks of comprehensive activities and neglect an overall process view as they do not contain a continuous mapping of activities and resources (such as personnel, rooms or equipment). It is reported that barely 60% of hospitals use a common documentation system for various disciplines and occupational groups in the OR area. In 25% of all cases the OR data are not even captured in common information resources [Bu04]. Under such circumstances, a process-oriented improvement of OR areas is strongly restricted as information on subsequent, structured workflows is not available. Although this documentation allows the recognition of symptoms of process deficiencies, e.g. conspicuities such as delays, it is insufficient for tracking the underlying causes.

Therefore, we refined the initial process model and transformed it in a Petri-Net model that contains additional information on the following aspects: The basic activities were partitioned in subtasks, and further preliminary and downstream activities (e.g. checking apparatus, preparing material) were included as well as activities concerning information handling (e.g. patient order, checking of patient records). Along with the refinement of activities, the mapping of involved personnel and resources was adjusted. This allowed a more sophisticated reproduction of resource usage, such as different attendance times of assistants and surgeons. Finally, process variations were modelled, spanning special activities (e.g. special patient positioning), the use of mobile apparatuses and alternative patient routings (e.g. returning ward transport via patient sluice instead of via recovery room).

The refinements were done according to on-site observations in a medical surgery unit of a university hospital and by interviewing process participants like medical doctors and medical care professionals. Finally, the model was validated and confirmed by these experts regarding the process structure and properties. Figure 1 presents the basic activities of a surgery and an extract of the refinement of the activity ‘patient preparation’. The latter exemplifies subtasks of the partitioned activity ‘patient preparation’ taking place after the patient is narcotized. It shows a more granular resource mapping of different OR-personal and the activities they are responsible for. Moreover it includes a process variation for the positioning of the patient. After the Patient is in the OR, regularly he/she is attached to the monitoring, lying in a standard position. However, in some cases a special positioning is necessary, according to the instructions of the surgeon. In these cases the positioning is done separately before the monitoring. Afterwards the patient is ready for the further surgical preparation.

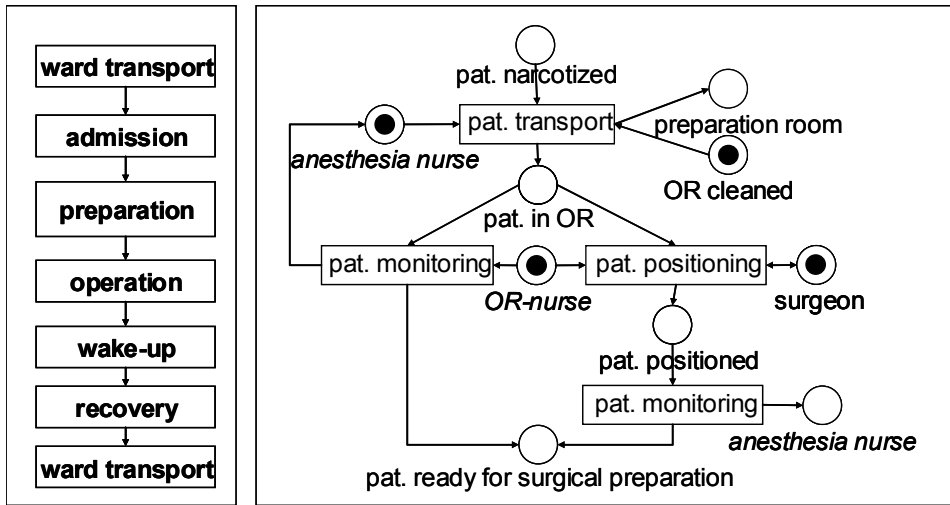


Figure 1: Basic activities of a surgery and extract of the refined patient preparation

2.2 Data collection

According to the refined process model, the relevant information was collected manually. This field study took place in a general medical surgery unit that is organised as service centre with a central surgery unit management and works with overlapping anaesthetizing procedures [Ha+05, Dex05]. To ensure a uniform time recording amongst the various personnel tasked with the registration of time points, we defined criteria specifying the perceptibility for the considered time points. The resulting set of data contains comprehensive information for 102 surgeries, covering ten working days with four parallel operating ORs. On average, 2.5 surgeries took place in an OR each day.

As some time points were collected in parallel to the standard documentation, we were able to compare them and to evaluate the quality of the standard documentation. Table 1 shows how much the time points documented in the clinic's system differed from the observed time points in reality. Some core times such as the transection start have been documented precisely, but others vary considerably. One reason is that when the personnel's full attention is necessary for the treatment of the patient, estimated time points are often documented ex post. Another reason is that not everyone has the same understanding or interpretation of the requested time points. For example it seems like for the time point 'patient in the OR' often the 'end of monitoring' is recorded, when the patient is ready for surgical preparation. Thus, for the time point 'patient in the OR' the values in the clinic's system differ from reality with a median of 34 minutes and better match the 'end of monitoring' that only differs with a median of 5 minutes.

	median (MED)	average (AVE)	standard deviation (SD)
	min	min	min
patient is ordered	18.5	26.0	16.4
start of admission	3	5.5	4.9
patient in the OR	34	43.3	31.8
↳ end of monitoring	5	9.3	12.4
transection start	0.5	1.4	2.7
suture end	4	8.8	12.3
patient leaves the OR	4	7.4	15.5

Table 1: absolute deviation of standard documentation from reality

These deviations show the problem of manual standard documentation as a secondary add-on load for OR staff and - regarding a detailed process analysis - they put the usability of this data into perspective. Especially, if a more detailed representation is required, there is the need to search for feasible, possibly automatic ways of process documentation.

3 Process analysis

Given the process models and the relevant information, the main task of the process analysis is to identify causes of process inefficiencies and relevant influencing variables that allow a proactive realisation of bottlenecks and process interdependencies before disturbances arise. The documentation and modelling of existing interdependencies between processes (including personnel, equipment and room resources) is the precondition for the identification of especially important and vulnerable process interfaces. The aim of the process analysis is to identify the basic information need for process optimization regarding those activities that influence the interplay of adjacent processes and determine the further course of the overall OR process.

The process analysis is performed in two consecutive steps. In the first step, we conducted statistical examinations of the collected data, concerning classical figures as indicators for process disturbances, such as delays or waiting times. In the second step, a simulative analysis of the OR model will be performed, testing important parameters in changing situations. In this paper we will present the results of the statistical analysis.

3.1 Statistical analysis

OR idle times

Regarding the OR processes as the central ones all other processes should align with, we examined the idle times of an OR. In this context, the OR idle time is used as an efficiency measure of an OR area. It gives an estimate of the optimization potential of a better process coordination and adjustment. In our study the median of the idle time of an OR is 23 minutes per day (5% of the average OR running time), see Table 2. Additionally, for the first operation in the morning we could observe a delayed transection time with a median of 15 minutes (3% of the average OR running time). In total this amounts to approximately 38 minutes (8% of the average OR running time) of unused OR capacity. Regarding the deviations from due times for the first patient in the morning, we see obvious differences between the median and the average. They are caused by the occurrence of statistical outliers that have to be examined separately, regarding special disturbances or process conflicts.

	median (min)	average (min)	variance (min)
OR idle time	23	25	20
preparation times			
anaesthetization (first patient in the morning) ¹	16	16	8
anaesthetization (during the day) ¹	30	31	19
Surgical preparation (first patient in the morning) ²	22	23	11
Surgical preparation (during the day) ²	22	23	9
¹ patient stay time in the preparation room, ² patient arrival at the OR until transection			
deviation from due times in the morning			
patient arrival at the sluice (after 7:40)	11	9	13
start of anaesthesia (after 8:00)	10	16	16
transection start (after 8:30)	15	21	19

Table 2: OR process figures

Delayed transection times in the morning

To explore the causes for delayed transection times in the morning, we first checked whether they result from extended preparation times in the morning. The data showed that the preparations taking place in the preparation room as well as the ones in the OR are not delayed in the morning (see ‘preparation times’ in Table 2). For anaesthetization, they are even shorter in the morning because the daily OR scheduling plans patients without special anaesthesia treatment as a first surgery. Moreover, there is no preliminary surgery that might occupy the OR and cause waiting times in the preparation room. Instead, it revealed that the patients already arrive delayed, and therefore pass succeeding activities with delays as well (see ‘deviation from due times in the morning’ in Table 2). At the sluice, half of the patients arrived late from 11 up to 40 minutes in the morning. Thus we can confirm the need of support for OR planning especially to adjust OR processes with the ones from wards and preliminary units.

Changeover time

During the day, OR idle times result as a delay between two succeeding surgeries. This implies a late preparation of the consecutive patient in the preparation room that might either be due to lack of anaesthesia staff or because of a tardiness of the next patient. In our study we see an average OR idle time of 17 minutes (MED 13, SD 14) between two succeeding surgeries. In 29% of the cases preparation was finished in time and the change of surgeries went on seamlessly, with an OR idle time under 5 minutes. Nevertheless, 22% were delayed due to a staff bottleneck leading to a late arrival of the anaesthetist and 49% were invoked by a late arrival of the patient. The causes for a late patient arrival at the preparation room can be specified in more detail: 31% patients were requested too late (later than 45 minutes before the release of the OR) and 18% were special cases with unforeseen disturbances. A late patient arrival caused process interruptions lasting from 10 up to 60 minutes with an average of 28 minutes (MED 22, SD 21).

This evaluation highlights two main influence variables for OR processes: the availability of anaesthetist staff for the overlapping anaesthetization and the patient request. Especially the manual patient request is very time consuming, requiring on average 7.5 minutes (MED 2, SD 13). In 16% of all cases the patient request reached the ward from 15 up to 40 minutes later than the surgeons order. These cases clearly show the need for better support of information communication. Moreover, the patient request does not only influence the OR utilization but also the need of staff for attending early patients in the preparation room. Therefore, the patient request should not only be facilitated but also adjusted to the development of the running surgery and the preparation need for the following patient.

Outliers

As indicated above, the analysis of outliers with especially noticeable delays uncovered various disturbances and problems.

Surgeons arrived at the OR on average 10 minutes after the patient (MED 7, SD 21). Assuming the patient is ready for transection 22 minutes after arrival at the OR (see 'surgical preparation' in Table 2) in 23% of cases the surgeons could be noticed late. This implies problems with the coordination of other processes the surgeon is responsible for, e.g. adjacent activities outside the OR. This tardiness also may be invoked by problems informing surgeons in a timely manner. The latter information intransparency is especially problematic if changes or emergencies occur and OR personnel has to perform time consuming manual coordination. In respect of that there were 6% cases with surgeons arriving later than 40 minutes.

In 3% of the cases, the patient sluice turned out to be a bottleneck and patients had to wait about 15 minutes before admission began. Surprisingly, these cases did not happen in the morning, when all patients for four ORs are supposed to arrive at the same time. Instead it happened during the day due to missing OR personnel. This occurred either because of problems with informing the responsible person or because of resource conflicts when all adequate staff was busy with other tasks.

In 13% there occurred delays, due to an inadequate preparation in advance of surgery. Causes were incomplete patient records with missing documents (such as laboratory values and findings of preliminary examinations) or inexact information (e.g. on the extent of the intervention and necessary coverage of anaesthesia). Other rare but still avoidable cases showed problems with missing patients' consents or with the patients' soberness. Inadequate preparation in advance of surgery regularly caused more than twice as long admission times, ranging from 12 to 30 minutes, and in two cases surgery even had to be cancelled. These disturbances could be reduced if necessary information could automatically be integrated into preliminary OR scheduling and control fulfilment of preconditions for surgery.

3.2 Simulative analysis

Statistical analysis showed first process deficiencies and clues for a more detailed information need in OR management. Moreover it is the primary task for simulative analysis to examine and quantify process and resource interdependencies regarding different OR designs in more detail.

Based on the derived OR process models, we rebuilt the OR area of the field study in a simulation model with all four ORs, spanning from sluice up to recovery room. In order to verify the simulation model, we have to evaluate whether the mapping of activities and subtasks of a surgery process is adequately comprehensive and whether the interplay and coordination of the four ORs (including the concept of overlapping anaesthetization) is represented close to reality. Therefore we verify the model according to process figures including figures for a single surgical process, e.g. patient throughput time and figures for the overall OR area, e.g. OR running times (see Table 3). Simulation showed a shorter patient throughput time than reality, with a median of 13 minutes. With an average of daily 2.5 surgeries per OR (see section 2.2) the OR running time consequently differed with a median of 34.5 minutes and approaches the estimated organisational optimization potential in section 3.1. This can be explained, as simulation is free from waiting times caused by communication problems and some negligible activities (such as conversation of staff and patients) were not represented in the model. Thus, altogether the simulation model adequately represents the reality.

	Deviation MED (min)	Deviation AVE (min)	Deviation SD (min)
Patient throughput time ¹	-13	-18.1	19.5
OR running time ²	-34.5	-37.5	15.6
¹ patient stay time from patient admission up to release from recovery room			
² from OR opening in the morning up to last patient leaving the OR			

Table 3: Model verification - deviation between simulative and real process figures

The model will serve as a testing environment for further examination of OR information need and respective potential for operational support. In addition to statistical analysis, the question shall be studied whether there are control points or influencing variables that are important in different OR designs and which ones show relevance only in certain situations. Therefore variations in OR layout shall be studied and different situations regarding homogenous or heterogeneous kinds of surgeries as well as short or long interventions (including process variations on necessary activities and resources).

4 Summary and Conclusions

In order to analyse and improve OR processes, it is necessary to have adequate process knowledge and information to be able to track process inefficiencies and their causes. Thus we studied current time-documentation schemes in OR literature and exemplary examined a real OR of a university hospital. Our observations revealed the need for a more precise process modelling and documentation. Hence, we refined existing OR process mappings as basis for a field study, to gain a comprehensive data collection. Referring to that data, we noticed problems concerning the validity of manual time documentation that showed need of IT support for data collection.

To specify the relevant information need, our aim is to condense our OR process model and extract important times, vulnerable processes representing core influencing variables and recourse interdependencies. Therefore, we performed statistical analyses on the data of our field study. These analyses revealed the effect of first control and influencing variables such as patient demand, the OR preliminary patient preparation including the quality of the patient record and resource interdependencies in bottleneck situations. Moreover it showed the need for supporting the monitoring and communication of real time OR progress to facilitate self coordination of involved personnel inside and outside the OR area. Another aspect is the need of support for preliminary OR planning to detect fragmentary, deficient patient preparation in advance of the OR to reduce avoidable process disruptions or cancellations of surgeries. Moreover, we built a close to reality simulation model as basis for further analysis regarding varying OR designs.

5 Future Work and Outlook

As the exemplary data collection was very detailed, we will in a subsequent step discuss relevant parameters and important information required for realtime support of OR management. Based on the results of our statistical and simulative analysis, an adequately comprehensive documentation scheme shall be developed.

In advance of the project IT based methods of data collection and process control will be studied. In order to realize a real-time process control environment we consider ubiquitous mobile systems (UMSs), such as real-time sensor systems (RFID, WLAN, GPS). These UMSs offer on-line data from different technologies to doctors, nurses and other process participants and enable the goal of real-time business process control [GM04]. Therefore, a conceptual framework for business process management has to integrate UMSs in order to control processes effectively [BN05]. Such a flexible approach can lead to truly real-time oriented process execution, where the execution of patient processes and resource flows can be effectively monitored to improve predefined service levels and treatment quality.

Due to the high complexity of the processes and workflows OR managers must have powerful tools for decision making. Software simulation tools can provide an effective framework to analyse and optimize the processes [Ch04], if they are integrated into the decision making process. Thereby, the simulation tool delivers analytical results of the soundness and performance of the process [Pi05]. As a result, OR managers, doctors and nurses can directly perceive the potential improvements of workflow performance through process reconfiguration within the simulation environment.

Acknowledgements

We want to thank the Land Baden-Württemberg for funding, and the staff of the Department of Anaesthesiology and Critical Care Medicine of the University hospital Mannheim for appreciation and cooperation in our field study.

References

- [ALS00] Arnold, M.; Litsch, M.; Schellschmidt, H.: Krankenhaus-Report 2000. Schattauer-Verlag, Stuttgart, 2000.
- [BCA02] Stellungnahme des Berufsverbandes der Deutschen Chirurgen und des Berufsverbandes Deutscher Anästhesisten: Datenanforderungen auf dem Personalsektor zur Abbildung von Prozessen im OP und zur Kalkulation der DRG. In: Anästh Intensivmed 43: 457-461, 2002.
- [BDH02] Barkaoui, K., Dechambre, P., Hachicha, R.: Verification and optimisation of an operating room workflow. System Sciences, 2002. HICSS. Proceedings of the 35th Annual Hawaii International Conference on (2002) 2581–2590.
- [Be03] Bender, H.J.: OP-Management - eine neue Aufgabe der Anästhesiologie. In: Anästhesiologie und Intensivmedizin, 44: 31-42, 2003.
- [BN05] Bellur, U., Narendra, N.C.: Towards service orientation in pervasive computing systems. In: International Conference on Information Technology: Coding and Computing (ITCC'05) - Volume II. (2005) 289–295
- [Bu04] Busse, T.: Spezialauswertung OP-Management. Ziel noch nicht erreicht: Eine Bestandsaufnahme. In: Führen und Wirtschaften im Krankenhaus 21:74-76, 2004.
- [Ch04] Chung, C., Simulation Modeling Handbook – A practical approach, CRC Press, 2004.
- [Cl00] Clade, H.: Krankenhäuser / Gesundheitsreform: Fallpauschalen als Mehrzweck-Waffe. In: Deutsches Ärzteblatt 97:A1394-5, 2000.

- [De05] Dexter, F.: Deciding whether your hospital can apply clinical trial results of strategies to increase productivity by reducing anesthesia an turnover times. In: *Anesthesiology* 103:225-228, 2005.
- [Ge+02] Geldner, G.; Eberhart, L.; Trunk, S.; Dahmen, K.; Reissmann, T.; Weiler, T.; Bach, A.: Effizientes OP-Management. In: *Anaesthesist* 51:760–767, 2002.
- [Ge+03] Gebhard, F.; Hartwig, E.; Isenmann, R.; Triebisch, K.; Gerstner, H.; Bailer, M.; Brinkmann, A.: OP-Management: Chirurg oder Anästhesist? Eine interdisziplinäre Herausforderung. In: *Anaesthesist* 52:1062–1067, 2003.
- [GM04] Gupta, P., Moitra, D.: Evolving a pervasive it infrastructure: a technology integration approach. *Personal Ubiquitous Comput.* 8(1) (2004) 31–41.
- [Ha+05] Hanss, R.; Buttgereit, B.; Tonner, P.H.; Bein, B.; Schleppers, A.; Steifath, M.; Scholz, J.; Bauer, M.: Overlapping induction of anesthesia: an analysis of benefits and costs. In: *Anesthesiology* 103:391-400, 2005
- [KKS76] Kwak, N.K.; Kuzdrall, P.J.; Schmitz, H.H.: The GPSS simulation of scheduling policies for surgical patients. *Management Science*, 1976, 22: 982-989.
- [LD99] Lowery, J. C.; Davis, J. A.: Determination of operating room requirements using simulation. In *Proceedings of the 31st Conference on Winter Simulation: Simulation---A Bridge To the Future - Volume 2* (Phoenix, Arizona, United States, December 05 - 08, 1999). P. A. Farrington, H. B. Nemhard, G. W. Evans, and D. T. Sturrock, Eds. WSC '99. ACM Press, New York, NY, 1999, S. 1568-1572.
- [LL00] Lauterbach, K.W.; Lungen, M.: Krankenhäuser: Neues Entgeltsystem nach US-Muster. In: *Deutsches Ärzteblatt* 97:A444-447, 2000.
- [Ma+95] Macario A.; Vitez T.; Dunn, B. et al: Where are the costs in perioperative care? Analysis of hospital costs and charges for inpatient surgical care. In: *Anesthesiology* 83:1138-44, 1995.
- [OW02] Opderbecke, H.W.; Weißbauer, W.: Datenanforderungen auf dem Personalsektor zur Abbildung von Prozessen im OP zur Kalkulation der DRGs. In: *Anästh. Intensivmed.* 43, 2002, S. 457-461.
- [Pi05] Pinedo, M. L., *Planning and Scheduling in Manufacturing and Services*, Springer, 2005.
- [Re+03] Reißmann, H.; Bauer, M.; Geldner, G.; Kuntz, L.; Schulte am Esch, J.; Bach, A.: Leistungs- und Kostendaten in der Anästhesiologie. In: *Anästh Intensivmed* 44: 124-130, 2003.
- [Ri02] Riedl, S.: Modernes Operationsmanagement im Workflow Operation. In: *Chirurg* 73:105-110, 2002.
- [SSB03] Schleppers, A.; Sturm, J.; Bender, H.J.: Implementierung einer Geschäftsordnung für ein zentrales OP-Management. In: *Anästhesiologie & Intensivmedizin*, 44:295-303, 2003.
- [ST99] Schumpelick, V.; Treutner, K.H.: Perioperative Organisationsabläufe aus Sicht des Chirurgen. In: *Chirurg* 70: 23-28, 1999.
- [Zö+06] Zöller, A.; Baumgart, A.; Denz, C.; Paulussen, T.; Schleppers, A.; Badreddin, E.; Bender, H.J.; Heinzl, A.: OP-Management: Nur eine Modererscheinung oder ein Konzept mit Nachhaltigkeit? In: *Deutscher Anästhesie Congress 2006*, Leipzig, accepted.