

# Integrating utilisation and productivity information in operating rooms

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**Abstract:** The management of operating rooms (ORs) is usually based on perceptions and is rarely supported by a structured framework for data analysis. This work shows how the medical and administrative informational flows and data sources about ORs already existing in hospitals can be organised and integrated in order to evaluate utilisation and productivity performances. The case of a large Italian hospital is considered.

Future research efforts will be focused on the evolution of the proposed approach towards a monitoring system to be included in a business intelligence framework for healthcare organisations.

Keywords: healthcare management, operating room utilisation, operating room productivity, database management, Italian hospitals

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## 1. Introduction

A modern healthcare organisation, characterised by efficiency and effectiveness goals, should be focused on the fair management of all its parts (Cagliano et al., 2011). Among them, surgical blocks are of paramount importance for hospitals as they represent the core of operational activities and involve a great number of technologies and resources. Thus, cost curbing and performance improvement should be necessarily achieved through a better allocation of production factors and an optimised organisation of the personnel working in operating rooms (ORs). The accomplishment of these tasks requires a deep understanding of the procedures and performances of ORs.

However, an investigation of Italian hospitals highlighted that the monitoring of OR functioning is rarely supported by a detailed data analysis or by a structured and well defined framework for performance measurement. Assessment is sometimes carried out in a sort of “by perception” way. This is mainly due to the national legislation about data collection and associated analyses. In fact, according to the health ministerial regulation, hospitals have to report just the monthly total surgery time and to specify whether peculiar medical equipment is in use. Moreover, every hospital has to track the hospital discharge documents, based on which the reimbursement for the institution is calculated, but it does not perform any specific utilisation and productivity analysis. Since no standard appraisal is requested, monitoring strategies are often quite superficial and they do not lead to a comprehensive knowledge of real process performance. (Salassa et al., 2009). Finally, the heterogeneity of the existing ICT infrastructures and, to be more precise, the not homogeneous diffusion of Healthcare Enterprise

Resource Planning (HERP) systems in healthcare organisations often cause a lack of reliable and consistent information (Jollis et al., 1993; Solberg et al., 2006). OR data collection is usually in part paper-based and in part computer-based and the same data are often stored in multiple databases.

These empirical observations are confirmed by literature that suggests that a similar situation can be found also in other countries.

Thus, on the one hand, data retrieving and analysis are not always perceived as necessary by managers, on the other hand, automatic or semi-automatic systems for performance measurement are sometimes not based on a common and consolidated framework for their implementation.

In this work we show how the informational flows and data sources about ORs already existing in hospitals can be organised and integrated in order to evaluate utilisation and productivity performances without gathering new pieces of information. In particular, we prove that the combination of both medical and administrative data, that are usually collected and analysed separately in a healthcare institution, provides meaningful managerial knowledge. The case of a large hospital in the North West of Italy is considered. The analysis of the current informational flows about ORs in a representative ward allowed to assess a set of parameters about utilisation and productivity not tracked by the hospital monitoring system. The obtained results were compared with managers’ perceptions.

The paper is organised as follows. Section 2 reviews the most relevant literature about informational flows and performance assessment in ORs. Section 3 introduces the

case study, details the current way of managing information in the analysed ORs, and presents some utilisation and productivity parameters that can be evaluated by integrating the existing datasets. Findings together with benefits and limitations of the approach are discussed in Section 4 and conclusions drawn in Section 5.

## 2. Literature review

In the last decades, significant research activities have focused on the development of methodologies for measuring OR performance (Strum et al., 1997; Tyler et al., 2003; Berry et al., 2008; Saha et al., 2009). In particular, much work has been carried out by authors such as Dexter and Macario (Dexter et al., 1999; Glenn and Macario, 1999; Dexter and Macario, 2004; Macario, 2006), who focused their studies on the definition of performance dashboards for ORs and on the management of anaesthesiology departments in terms of staffing and costs. Another contribution to this field was given by Abouleish (Abouleish et al., 2002; Abouleish et al., 2003), whose work mainly addresses productivity of anaesthesiology departments. A wide literature dealing with planning and scheduling of major operations in ORs and with staff timetabling also exists (Cardoen et al., 2010).

Two are the main limitations of the above studies. On the one hand, they do not suggest what relevant data sources should be considered and what information should be collected in order to get the results expected by managers. On the other hand, they do not present a defined and codified approach for ICT-based evaluation and management of OR efficiency.

A number of papers about both ICT technology and HERP diffusion and implementation can be found in literature (Devaraj and Kohli, 2000; Jha et al., 2008; Jha et al., 2009). Common issues mentioned by most of these studies are related to a substantial heterogeneity in the implementation of ICT solutions and to a scarce adoption of HERP systems within healthcare organisations. Such situation is due to significant expenses required for integrating existing technological facilities, to large efforts needed for providing human resources with the required training, and to the uncertainty about the benefits that can be achieved. It is worth mentioning that a codified framework for analysing the advantages of implementing ICT solutions is still missing. In a similar way, there is a lack of assessment of the actual return of value of large technological investments within enterprises, and especially within healthcare organisations (Brynjolfsson, 1993; Brynjolfsson and Hitt, 1996; Brynjolfsson and Hitt, 1998).

Thus, the works discussed above suggest that healthcare managers face substantial obstacles to achieve valuable performance estimations. Moreover, only a small portion of hospitals in a given country possess those key components of an HERP system, although often not integrated, that would enable to carry out a constant monitoring of ORs.

## 3. Case study

### 3.1 The case hospital

The case study focuses on a hospital located in the North West of Italy. The selected structure is one of the largest hospitals in the country, with 1260 beds divided into 1076 ordinary hospital beds and 184 day hospital beds. The hospital counts 68 wards and 35 ORs, organised into 15 surgical suites, performing roughly 21000 cases per year. About 1014 physicians work in such healthcare organisation, including 253 surgeons and 144 anaesthetists, as well as approximately 2100 nurses and 1300 auxiliary hospital attendants.

We analysed a surgical ward composed of three ORs where about 2000 cases are performed every year concerning the general, oncogenic, and laparoscopic specialties.

Such ward was chosen because it is responsible for non-urgent surgery, and thus it is able to represent the normal flow of activities in the hospital. The official standard OR operating hours are 7am thru 8pm: the first hour is spent on room preparation and pre-operative activities and, in general, daily cleaning takes place from 7pm until 8pm.

It is important to highlight that not all the wards in the hospital benefit from the same information technology tools and infrastructure. Although the hospital is introducing a standard database framework in all its departments, this system is not yet available in every ward. Also, the surgical ward at issue is not supported by any business intelligence software, which would help managers to track the actual performance of ORs.

### 3.2 Methodology

With the aim of providing an approach that exploits the available knowledge basis, our study relies on the informational flows already existing in an healthcare organisation and usually employed for other purposes. This choice is of paramount importance especially when the proposed analysis becomes the starting point of a systematic performance monitoring tool to be implemented by all the ORs in a hospital.

Thus, no additional data were gathered nor a campaign of historical data collection was carried out in the present case study. Data about major surgical operations, managing rules of surgical blocks, and reimbursement files were gathered from both administrative and clinical databases and analysed. In addition, interviews and questionnaires to personnel directly involved in ORs activities were conducted in order to get information not recorded by the main database system.

These efforts gave us a clear idea of the processes underlying everyday activities and their associated data collection.

Based on the acquired knowledge, we processed numerical data in order to assess a set of OR parameters considered to be of interest by the selected healthcare organisation but not tracked by the current hospital monitoring practices. All the calculations have been performed by means of Minitab software package (Minitab Inc., 2011).

The study was carried out in close collaboration with OR personnel, anaesthetists, and people from information system and administrative departments. Combining different perspectives allowed us to manage clinical aspects, statistical analysis, database management, and administrative rules in a comprehensive way.

### 3.3 Current OR reporting system

For the purpose of the reimbursement by the regional government and in order to monitor the resources and expenses inside the hospital, the following reporting system is currently in place.

The hospital generates a report about OR usage every four months but such document does not include many important aspects such as opening delays, average turnover time, and activities of main actors like surgeons and anaesthetists.

Each single OR produces a monthly report tracking its activities by using a local Database Management System. This report is cross-referenced to administrative data from the HERP system, in order to confirm the quality of the information, and presents details about patient entrance time, time of anaesthesia induction, and start time of surgery.

In addition, any OR develops descriptive statistics regarding productivity every three months. The number of actual working days is recorded together with a work index defined as the ratio between the number of hours actually spent in the OR and the number of planned OR hours.

### 3.4 Mapping the OR informational flow

The first step in the integration of data about OR utilisation and productivity is mapping the present informational flow, with the purpose of understanding how it is managed and identifying those activities needing to be supported by more information.

To this end, the main actors involved in the exchange of information about surgical operations and room occupation are identified. They are the following:

- *Chief Medical Department:* the Statistics Office of such department prepares the specific paper form for collecting data about surgical cases, receives the completed forms from the wards, and checks the data they contain. On this basis, it carries out a performance analysis and creates a report that is sent to other process actors, such as top clinicians and Controlling. After receiving feedback on the report, the Statistics Office communicates it to the OR managers.
- *OR personnel:* head nurses fill in the forms for data collection. They may delegate this task to other OR personnel.
- *Health Department of the Region Council:* the Health Department of the Region Council periodically asks hospitals to provide an analysis of surgery time. It then communicates the associated data to the

Ministry of Health, also reporting to hospitals any criticalities.

- *Wards:* top clinicians are the last information recipients because they get a yearly report about the analysis of OR data and can ask clarifications on the documented performance.

The OR informational flow in the hospital at issue can be divided into a number of macro-phases that follow one another in time:

1. *Preparing the OR form:* the form for OR data collection is created. The Chief Medical Department defines the structure of such document and may update it in order to make the form more easy to understand and use. This macro-phase may have not been performed for a long time, often for some years, especially when the form is already clear and does not need to be modified.
2. *Filling in the OR forms and sending them to the Chief Medical Department:* on a daily basis, the head nurse, or other personnel, enters the data about the time and modes of the cases performed in a given OR and surgical block. The data entry should be validated by specifying both the open and the close time of the OR and the surgical block. At the end of the month, all the OR forms related to each day of activity are sent to the Chief Medical Department.
3. *Checking OR data and entering them into the database:* the Statistics Office of the Chief Medical Department checks the data contained in the OR forms coming from the surgical blocks. Both a syntactic and a semantic analysis are performed concurrently. The syntactic analysis is aimed at detecting orthographic mistakes, syntax mistakes, and data not clearly expressed. The semantic analysis looks for possible incongruities in the recorded information and missing data. In order to amend data, the Statistics Office may consult the hospital discharge documents, the official papers giving all the details about the hospitalised patients. As an alternative, the OR personnel that filled in the forms may give clarifications about mistakes or ambiguities. After checking the correctness of the data from the OR forms, they are stored in a Microsoft Access database, so that they can be easily used for follow-up analyses.
4. *OR data analysis and reporting:* every three months, the Health Department of the Region Council sends the Chief Medical Department of the hospital, and in particular its Statistics Office, the request for an analysis of the surgery time in the surgical blocks. The results of such analysis will be sent to the Ministry of Health. If the received data present some criticalities, the Health Department may inform the Chief Medical Department of the hospital that in turn will inform the surgical block and the ward at issue.
5. *Yearly summary report on ORs:* every year, based on the information received by the surgical blocks, the

Statistics Office creates a summary report presenting some performance indicators about the utilisation and the occupation of ORs, such as the number of cases or the total surgery time. This report is sent to all the surgical blocks of the hospital and a meeting with OR managers and the Chief Medical Department may be organised in order to discuss the achieved results.

### 3.5 Integrating OR utilisation and productivity information

Based on the understanding of the OR informational flow, data about the planning and scheduling of resources were collected and processed, with the aim of assessing utilisation and productivity performances and comparing them with managers' perceptions. We chose such organisational aspects because nowadays they are considered of paramount importance for an optimised resource management in operating theatres.

The data the present work focuses on are not currently integrated in the informative system that has been implemented in the main departments of the case hospital. Basically, the input data come from both medical and administrative datasheets. As far as medical sources are concerned, the case book, including the OR forms, is considered, whereas administrative sources embrace datasheets about actual worked hours of personnel and basic information on people and equipment (e.g. internal code, name of the resource, availability, etc.).

Following a discussion of the most relevant parameters we tracked in this study.

Figure 1 shows the distribution of the start time of each major surgical case in the three ORs at issue over one year. Managers were particularly interested in this piece of information as they were trying to corroborate the adopted scheduling strategy. They regard the balancing of the number of cases during the daily hours available for surgery as a relevant proxy for OR productivity.

Results clearly reveal a strong preference to set surgical operations before 12:00 pm, that means that surgeons tend to schedule cases in the first half of a working day.

The distribution of the durations of major surgical cases performed during one year in the three ORs is presented in Figure 2. As it can be seen, most of the operations are between 1 and 4 hours long. This information, combined with the one given by Figure 1, shows that planning efficiency is adequate in the analysed surgical block. According to the distribution of durations, Figure 1 should present a second peak around 12:00 pm; the peak is shifted towards bins covering the range from 10:40 am to 12:30 pm. Furthermore, a third peak in Figure 1 is located around 3:30 pm. Such peak is lower than the previous ones because the risk of overutilisation of ORs is high and only few, perhaps less complex, operations are scheduled after 3:30 pm.

Figure 3 reports the scatter plot of start time and duration of major surgical operations performed over one year in the three ORs under consideration.

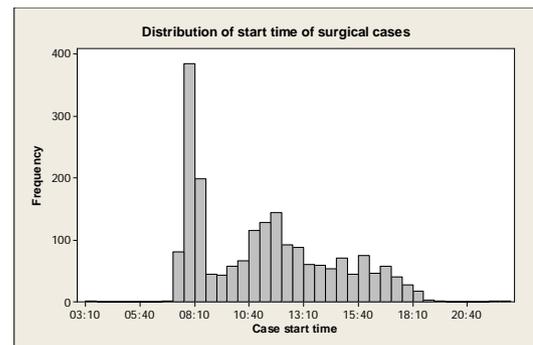


Figure 1. Distribution of start time of cases

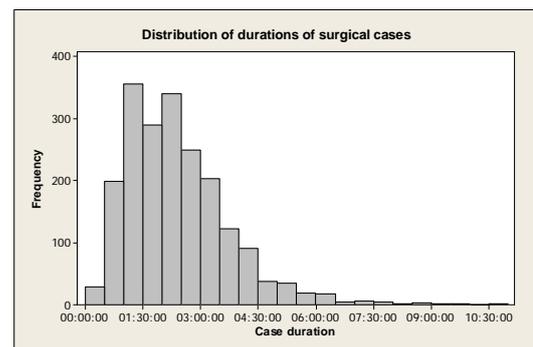


Figure 2. Distribution of durations of cases

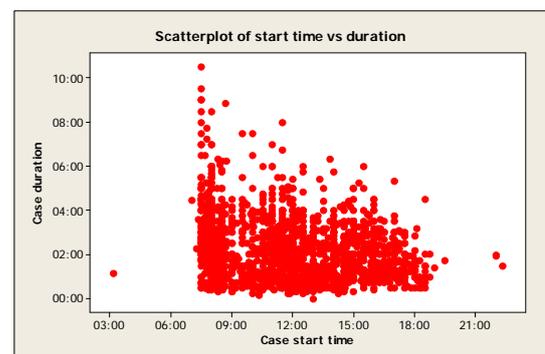


Figure 3. Scatter plot of start time and duration of cases

This information is significant because it completes the overview about OR planning. A decreasing trend can be identified, meaning that long lasting cases are mainly scheduled early in the morning. This practice is not surprising as in scheduling of OR utilisation priority is given to more complex and lengthy operations.

These results confirm that the planning and management of the three ORs are globally correct for the studied surgical block.

The investigations discussed so far are about a surgical block as a whole. However, our approach also allows more detailed analyses. This aspect is of paramount importance when surgical blocks are made up of more than few rooms, as well as when operating theatres are not grouped into blocks or when they are characterised by heterogeneous cases with very different surgery time.

OR managers in the case hospital were interested in deepening the knowledge about the functioning of the single rooms of the block at issue in order to identify possible differences among them.

To this end, we first performed a benchmark of the durations of surgical operations taking place over one year in each OR. Results are shown in Figure 4.

Although each room presents its own peaks in the distribution of durations, the three ORs do not show macroscopic differences and the trends are similar. Comparing the durations of cases taking place in different rooms is crucial when one of them is dedicated to special surgery. In fact, in such a case, particular attention should be given to the planning and scheduling of activities in that OR.

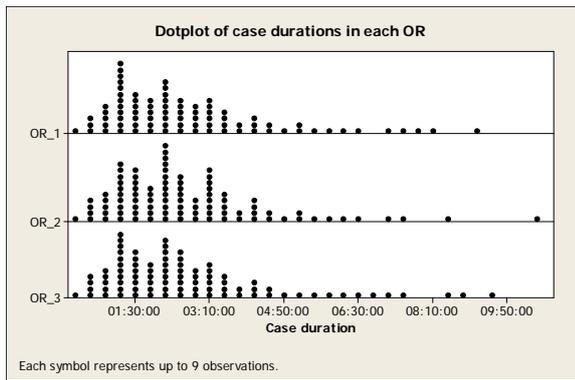


Figure 4. Durations of cases in each OR

Table 1 reports the number of cases, the cumulative surgery time, and the average surgery time, for each room and in total, over one year. The number of operations and the cumulative surgery time of Room 2 are much greater than those of Rooms 1 and Room 3, even though nearly the same kind of surgery is performed in the three rooms. Table 2 presents the average surgery time, the average number of cases, the average turnover time, and the total utilisation time (including both surgery time and turnover time) for each room and in total on a daily basis. Let us note that the turnover time includes the wake-up time. Again, the total utilisation time for Room 2 is significantly longer than the ones for Rooms 1 and Room 3. Moreover, the average turnover time of Room 3 is shorter than for the other rooms because very similar kinds of cases are usually performed in this theatre.

These results demonstrate that a detailed analysis is able to uncover differences in the performances of the three ORs that would not be detected by a global assessment of their functioning.

OR	# cases	Cumulative surgery time	Average surgery time
1	621	1413 h 33 m	2 h 16 m
2	739	1718 h 10 m	2 h 19 m
3	647	1450 h 50 m	2 h 14 m
<b>Total</b>	<b>2007</b>	<b>4582 h 33 m</b>	<b>2 h 16 m</b>

Table 1. Yearly OR performances

OR	Average surgery time	Average # cases	Average turnover time	Total utilisation time
1	5 h 56 m	2,6	1 h 04 m	7 h 39 m
2	6 h 59 m	3,0	1 h 03 m	9 h 05 m
3	6 h 21 m	2,8	0 h 51 m	7 h 55 m
<b>Total</b>	<b>6 h 26 m</b>	<b>2,8</b>	<b>1 h 00 m</b>	<b>8 h 15 m</b>

Table 2. Daily OR performances

In order to understand how the utilisation and productivity performances of the analysed ORs impact on the economic outcomes, the yearly reimbursement associated with the cases performed in the three rooms was analysed. Not surprisingly, the higher number of surgical operations taking place in Room 2 makes the related reimbursement outperform the ones of the other two rooms.

#### 4. Discussion

The careful consideration of the results of the analysis enabled to identify the main critical areas needing attention. To be more precise, we understood that something was not working as according to the managerial perceptions. In particular, OR managers perceived a heavier workload than what resulted from the present study. In general, our analysis made the case hospital aware of the fact that a more effective use of available human and technological resources is possible. To this end, the work discussed in this paper is intended to be a first step towards a more general understanding of OR performance and a reengineering of organisational and logistics flows in the operating theatres of the hospital.

From a theoretical point of view, the developed methodology is extremely flexible because it allows the integration of additional data about surgical blocks with the aim of carrying out a more thorough assessment. Thus, it may become the core of a wider structure involving other data flows relevant to healthcare managers. Also, the method can be easily adapted to different needs for frameworks to evaluate performances in healthcare systems. Each decision maker can focus on a particular set of data in order to estimate the parameters of interest. Furthermore, it is straightforward and entirely relies on the informational flows already existing in hospitals.

Finally, a great value of our methodology is the ability to extract information about performance by combining medical and administrative data, that are usually tracked separately in healthcare organisations.

However, the presented approach suffers from some limitations. This preliminary work relies on a qualitative analysis of results. Moreover, it does not allow to achieve a comprehensive understanding of how OR processes are carried out.

Future research efforts will be directed towards the transformation of the approach discussed in this paper

into a monitoring system to be integrated in a business intelligence framework for hospitals. On the one hand, new data flows will be included, such as those about personnel, that represents one of the crucial resources for healthcare activities. On the other hand, a dashboard of indicators about the efficiency and the effectiveness of both human resources and processes will be developed in order to constantly measure and control performances.

## 5. Conclusions

The present work suggests that the integration and organisation of data already existing in a hospital can create new knowledge about ORs, helping to effectively monitor operating suite behaviour, especially when no HERP systems and structured assessment tools are in use. The application of the approach to three ORs in a large Italian hospital allowed to identify issues not highlighted by managers' perceptions.

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