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Operating theater planning in Flanders: Results of a survey

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Abstract

This paper presents an overview of the operating room planning and scheduling practice of hospitals in Flanders (Belgium). An electronic survey was sent to 95 hospitals in which surgeries are performed, which eventually resulted in a response set of 52 hospitals (55%). The questionnaire did not only focus on issues related to the elective (inpatient and outpatient) planning and scheduling process, but also questioned how hospitals currently deal with the occurrence of non-elective surgeries (urgencies and emergencies). We indicate what goals health managers try to achieve and how this planning is established. We furthermore pay attention to some possible disruptions to the schedule and the corresponding anticipatory methods. Despite the proliferation of computerized planning and scheduling procedures proposed by the scientific community, the implementation rate of satisfying technological planning or evaluation systems still seems to be low. In order to increase the operating room efficiency, a closer cooperation between the academic institutions and the practitioners should be encouraged.

Keywords: health care, operating room, planning and scheduling, survey

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1 Introduction

The increased pace of change that characterizes today's society has a major impact on the management strategies applied to business processes. Nowadays, the era of mass production, which is merely process-oriented and focused on financial costs, seems to be repressed by strategies that address flexibility and agility [6]. The primary objective now is to simultaneously improve costs, quality and time aspects and relate these issues to both the process and the customers. Since these outputs largely depend on the accuracy by which operations management techniques are applied, various planning and scheduling problems have been studied in the literature. Although such techniques and insights mostly relate to industrial domains, such as machine scheduling or project scheduling, they also apply to the service sector. These services even tend to be more complex than their industrial counterparts, as they explicitly take human factors into account.

In order to develop effective planning and scheduling procedures, a thorough knowledge about the setting in which these methodologies have to be applied is indispensable. Moreover, the availability of valuable insights does not guarantee that they are implemented and used in practice, which eventually may result in a substantial gap between theory and practice. In this paper, we examine the current practice of Flanders' hospitals with respect to the operating theater planning and scheduling and try to evaluate the above research questions. We present findings that result from a larger survey programme in which Flemish hospitals were also questioned about appointment scheduling [11] and nurse rostering [16]. We restrict the focus to the operating theater, though, as this facility has a major impact on the performance of the hospital as a whole. It is furthermore a challenging unit as it unites many stakeholders with conflicting preferences [9] and is characterized by scarce, costly and interrelated resources.

The literature provides only few studies in which the current practice of operating room

management is described and evaluated in detail. Sieber and Leibundgut [15], for instance, surveyed the public hospitals in Switzerland on information about the structure and organization of the operating rooms as well as their opinions and expectations about the management (35 respondents). Although the respondents express their awareness of the importance of an adequate information system, results indicate only poor operating room management performance. The authors furthermore provide best practice guidelines as a helpful tool for the hospital management to improve their current practice. Gemmel and Bourgonjon [8] also report on the use of a questionnaire to evaluate the management of the operating theater. The results of a survey in Flanders (61 respondents) were used to illustrate some general managerial insights with respect to the planning and scheduling of surgical patients. Since our target population corresponds to theirs (see Section 2), we exploit in Section 4 the opportunity to examine whether Flanders' practices with respect to the planning and scheduling of operating rooms have evolved over time.

The remainder of this paper is structured as follows. In Section 2, we discuss the design of the survey and delineate the target population. Section 3 provides information on the response rate of the survey and indicates its most important results. Section 4 concludes this paper and provides a discussion on the (mis)match between the current practice of operating room planning and scheduling in Flanders and the recent developments that are addressed in the scientific literature. As mentioned in the previous paragraph, we furthermore briefly indicate whether the results of Gemmel and Bourgonjon [8] differ from the recent findings which are presented in this research paper.

2 Methods

Starting from the set of Belgian hospitals provided by the Belgian Hospital Association [3] in 2006, we restricted the target population of the survey to those hospitals that are situated in the Flemish Region. Note that the public health affairs in Belgium are currently not addressed at the federal level. As we only focus on the Dutch-speaking part of Belgium, linguistic difficulties are furthermore excluded. Our search eventually resulted in 95 hospitals (both private and public) that are equipped with a functional operating room complex. All hospitals received by the end of November 2006 an electronic questionnaire by e-mail. We preferred this electronic format to the regular postal services as it allows for an automated registration of the answers in a spreadsheet application. Moreover, it is a quick, cost-effective and user-friendly method. In order to increase the response rate, reminders were sent by e-mail approximately one month after the initial submission. Unlike the first e-mail, which was sent to the general information desk of the hospitals, this second e-mail was directed to the employee responsible for the planning of the operating theater as detailed contact information was retrieved from a preceding telephone call. We ended the registration of responses by the beginning of March 2007.

The questionnaire was kept as brief as possible (a printout of about 7 A4 pages) and covered, next to general questions about the institution, issues related to the operating room planning and scheduling process of both the elective and the non-elective surgeries. For most of the questions, which are either quantitative or qualitative in nature, we suggested a list of possible answers. Check boxes, radio buttons or edit controls were provided to facilitate the decision process or to rank the alternatives. Furthermore, respondents were able to specify their answer or provide a new entry when no match in the suggested list could be found. The participating hospitals received a summary of the results afterwards.

3 Results

In this section we present the results of the survey. We first elaborate on the response rate and check whether the composition of the represented hospitals is well balanced. Second, we highlight and visualize some of the most interesting findings of the questionnaire, both with respect to the development of the surgery schedule and its actual realization.

3.1 Response rate

The first mailing resulted in 39 responses, whereas the second one added another 13 responses. This total of 52 responses implies a response rate of 55%, which is close to the 58% that was encountered by Gemmel and Bourgonjon [8]. About 62% of the respondents clearly indicate to be the head nurse of the operating theater. Since hospitals were free to choose the profile of their respondent, it seems that the function of head nurse is the most appropriate to assess operating room planning and scheduling practices in Flanders. This observation deviates from the view expressed by Sieber and Leibundgut [15], as anesthesiologists were addressed in their survey.

We added Figure 1 to depict whether the entire population of hospitals in Flanders is well represented by the 52 hospitals of the response set. In Figure 1 (a), we categorize the hospitals in intervals according to the number of available operating rooms. About 85% of Flanders' hospitals has less than 10 operating rooms at their disposal, while this capacity corresponds to about 80% of the hospitals in the response set. For each interval, we notice only slight deviations (at most 3 percentage points) between the percentage of hospitals in Flanders and the percentage of hospitals in the response set. This implies that with respect to the number of operating rooms, our response set is quite representative for Flanders in its entirety. A similar

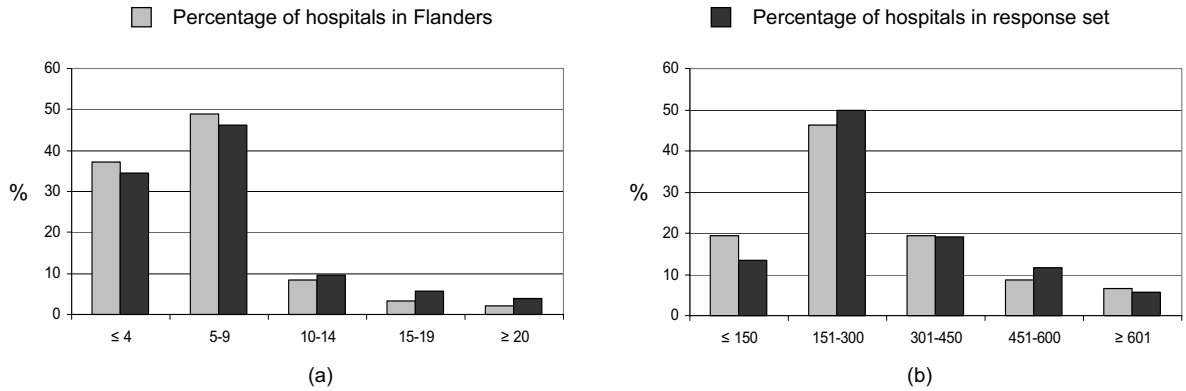

Figure 1: Indicating whether the sets of respondent hospitals is representative for Flanders with respect to (a) the number of operating rooms and (b) the number of hospital beds

reasoning applies to a categorization of the hospitals based on the available number of hospital beds, as depicted in Figure 1 (b). From this figure we see that the most important category of hospitals in Flanders consists of hospitals with a capacity of beds between 151 and 300 (46%). In the response set, about 50% of the hospitals fall into this category. The largest deviation in percentage points between the response set and the entire population of hospitals exists for hospitals with a bed capacity of maximum 150 beds. However, since this deviation is barely equal to 6 percentage points, we consider the bias to be negligible and hence conclude that the response set is also with respect to the hospital bed capacity representative for Flanders.

We asked the hospitals for the number of surgeries that they have performed in 2005. Most of the hospitals in the response set performed less than 10000 surgeries (48%). About 32% performed between 10000 and 20000 surgeries. The remaining hospitals accounted for more than 20000 surgeries (11%) or did not answer the question (9%). While 41% of the hospitals are satisfied with the current operating room capacity, about 59% indicate to expand their capacity in the future. Two major reasons were mentioned to justify this expansion. Either the operating room capacity is insufficient to satisfy the current demand for surgeries (48%), or it is insufficient

to cope with the future demand for surgeries (30%). By 2020, Etzioni et al. [7] predict significant increases in the workload of surgical specialties in the United States of up to 47% as a result of the aging population, although these increases may vary widely by specialty. Other reasons to justify the operating room capacity expansions (22%) are rather strategic in nature, such as the construction of a stand alone ambulatory center. Note that an increase in the number of operating rooms will probably trigger a linear increase in the number of hospital beds too, as the correlation coefficient of these variables, based on the entire population of hospitals in Flanders, is equal to 0.95. Alternatively stated, the scatter plot depicted in Figure 2 shows that there is a strong linear and positive relation in Flanders between the number of operating rooms and the number of hospital beds.

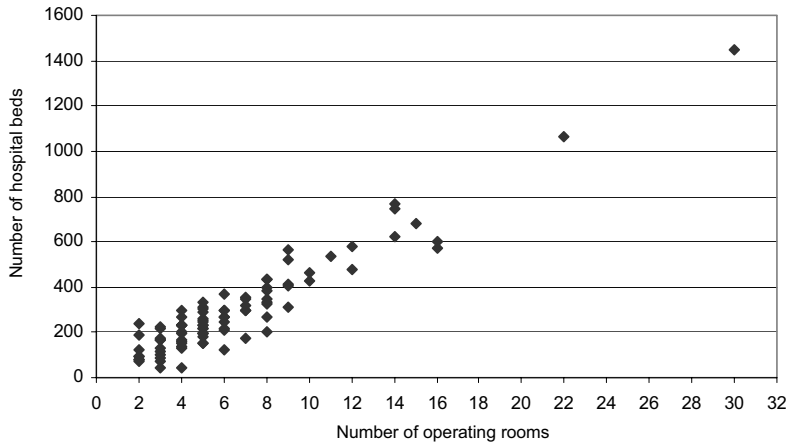

Figure 2: Visualizing the linear relation between the number of operating rooms and the number of hospital beds

3.2 Surgery schedule development

Various objectives may be addressed during the development of the surgery schedule. We asked the respondents to select from a predefined list three objectives that are, in their opinion, im-

portant. They furthermore had to sequence their three important objectives according to their preferences (important, more and most important). The results are summarized in Figure 3. About 89% of the respondents indexed the high utilization of the operating theater (h) as important, which is the highest score that was obtained over all the objectives. The avoidance of overtime in the operating rooms (g) also seems to be highly important (82%). At the other end, constructing surgery schedules in such a way that the post anesthesia care unit (a) or the intensive care unit (b) can be managed efficiently, does not seem to be of major interest to the respondents (respectively 4% and 7%). Only few respondents specified some other objective, i.e. an objective that was not suggested in the predefined list, to be important (11%). One such objective is, for instance, to maximize the ease of planning and scheduling. For each objective (a-h), Figure 3 also provides a horizontal bar in which we only focus on the set of respondents who indicated that the particular objective is important. More specifically, we indicate for that limited set of respondents who ranked the objective as the most important, the 2nd most important and the 3rd most important (expressed in percentage). Let's focus once more on the high utilization of the operating theater (h). We mentioned that 89% of the respondents indicated that this is an important objective. Although this percentage is very high, it would be less powerful if none of the respondents ranked this objective as the most important one. From Figure 3, we see that about 64% of these respondents indexed objective (h) as the most important, 32% as the 2nd most important and 4% as the 3rd most important. The interpretation of the horizontal bars should hence always be in the perspective of the percentage of respondents who indicated its importance, and vice versa.

Next to the decision about the objectives that have to be achieved, hospitals also have to think about the way to accommodate the demand for surgery properly. In particular, hospitals

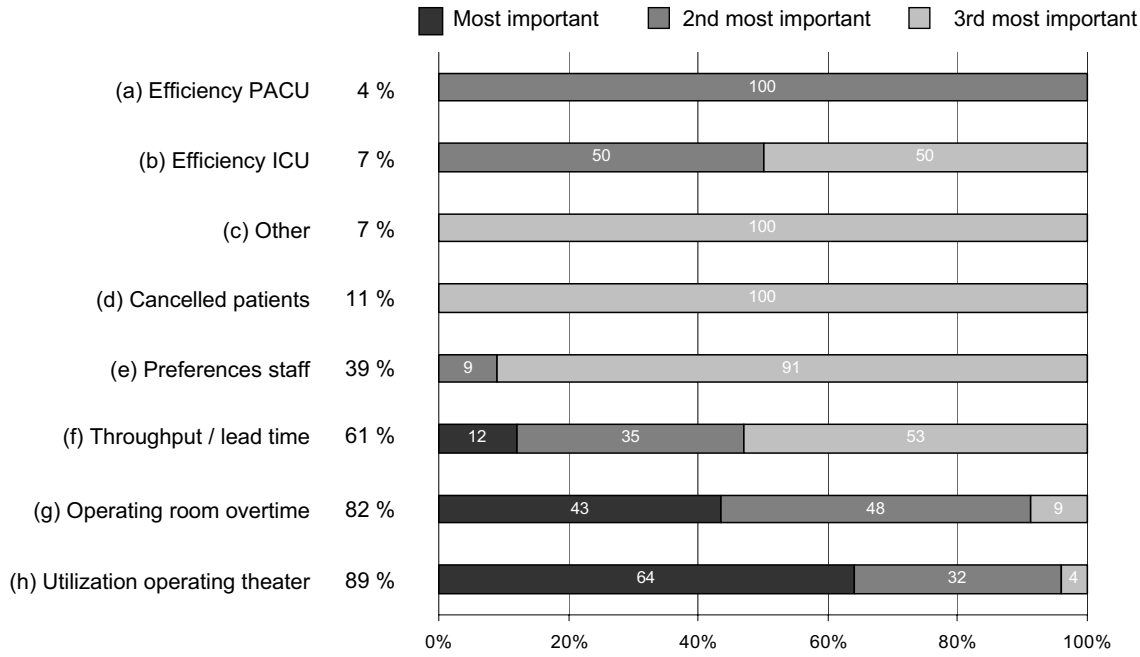

Figure 3: Importance of various objectives applied to the planning and scheduling of the operating theater

do not only have to decide on the amount of operating room time to assign to surgeons or disciplines, but also on the time or date. Results of the survey indicate that elective surgery, i.e. surgeries that can be well planned in advance, is in general planned from Monday to Friday (78%). Only a few respondents clearly confirm to perform some elective surgery in the weekend (15%). The remaining 7% of the respondents provided a blank answer. Three major assignment policies are described in the literature [10, 12]. First, it is possible to reserve an amount of operating room time (blocks) solely for cases of specific surgeons or medical specialties. This system is often referred to as block scheduling. Second, operating room time assignments may occur according to an open scheduling policy. In this policy, no blocks are assigned in advance and cases are treated on a first come first served basis. Modified block scheduling represents

the third assignment policy. This system is either a combination of the preceding policies or a variant of the block scheduling policy in which unused but reserved time is released at an agreed-upon time before surgery. With respect to our response set, only a minority of the hospitals in Flanders currently applies block scheduling (4%) or open scheduling (2%). Most hospitals (94%) favor a modified block scheduling policy. All hospitals in this large set confirmed their use of a specific release time to free unused block capacity. About 66% indicated to release operating room time less than 24 hours before the day of surgery. 16% have a release time that is between 24 and 48 hours before the day of surgery, while 18% indicate to release capacity more than 48 hours in advance. Since the required accommodation of operating rooms may differ between specialties, block scheduling or modified block scheduling seems to be inevitable to guarantee that the operating room is suitable for certain procedures. About 30% of the hospitals in the response set indicate that their operating rooms are capable to accommodate any surgery. The remaining 70% have a set of non-identical operating rooms. We asked this set of respondents to what extent operating rooms may differ. The results show that differences occur in size (69%), fixed equipment (50%) or other aspects (19%), such as the treatment of air flows or the proximity of inventory (logistics).

A popular way to schedule patients in such a way that the objectives of the hospital are achieved, is the use of simple priority rules. Since this list of rules is practically infinite, we asked the respondents to list some of the rules they try to incorporate. Not surprisingly, a variety of rules was obtained: schedule outpatient surgeries first, surgeries of children first, perform surgeries in the sequence they were added to the schedule, surgeries with the longest processing time first (or last), surgeries with the shortest processing time first, group surgeries of the same type and perform them consecutively, latex allergy patients first, contaminated patients last, etc.

We do not provide numerical results, as it is possible that hospitals actually use rules that they did not even mention in the survey. It should be clear that the priority rule which states that outpatient surgery is preferably performed before the surgeries of inpatients, applies to hospitals which schedule an amalgam of inpatients and outpatients in the same operating room. About a quarter of the respondents (24%), however, try to separate day-care or outpatient surgery from inpatient surgery.

Achieving multiple objectives simultaneously is challenging as they are often interrelated and even conflicting. This implies that trade-offs may occur and priorities have to be stated while determining the operating room planning. Since this is a complicated task (see Section 4), software may assist in the planning phase. Figure 4 indicates the presence of information technology and optimization software in order to develop the surgery schedule. Surprisingly, more than half of the respondents (56%) still construct surgery schedules without software support although this manual approach is time-intensive and often results in suboptimal schedules (a). However, the use of software is no guarantee to obtain a reliable schedule. About 26% of the

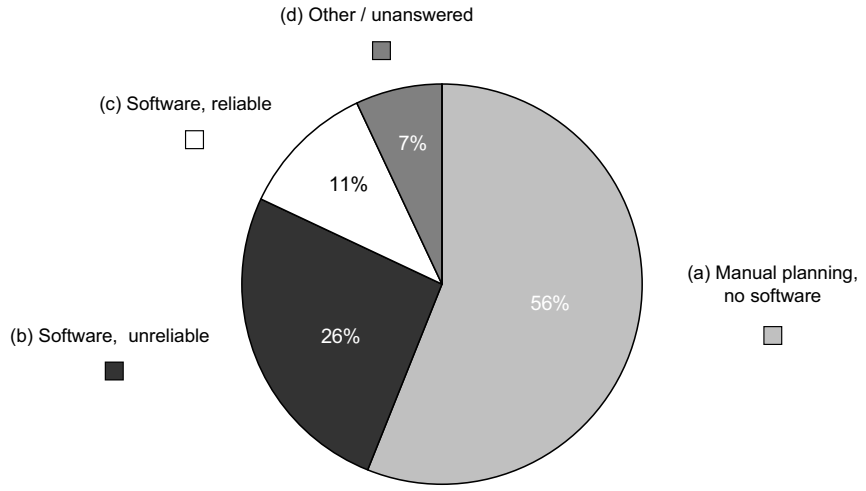

Figure 4: Visualizing the proportion of software use in the development of surgery schedules and its corresponding reliability

respondents indicate that their software produces schedules which definitely have to be checked for errors (b). Only 11% of the respondents confirm that their software system is reliable and hence produces qualitative output (c).

The accuracy of surgery schedules obviously depends on the estimation of the surgery durations. We questioned the hospitals how these estimates are obtained and visualized the results in Figure 5. We identify three approaches that are almost equally applied in hospitals in order to estimate their surgery durations, namely by analyzing historical data using software (a, 30%), by the surgeon who will perform the specific surgery (b, 30%) or by a discussion between the head nurse and the surgeon (c, 24%). All hospitals that produce reliable surgery schedules using software also estimate their surgery durations using software. About 11% of the respondents report that the head nurse estimates the surgery durations (d). The remaining 5% represent alternative approaches (e), such as the combination of software support and personal experience to estimate the durations. Remark that about 65% of the hospitals do not rely on any software support.

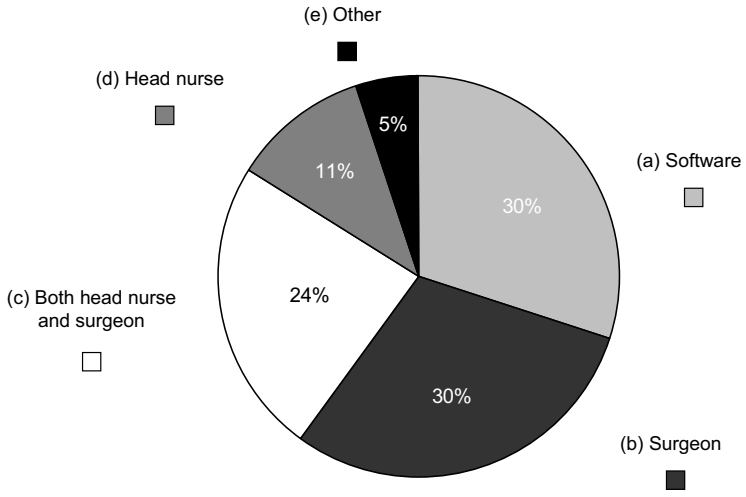

Figure 5: How to estimate the surgery durations

3.3 Realization of the surgery schedule

The actual or realized surgery schedule often substantially deviates from the planned schedule. In Figure 6, we list 8 possible causes of a disrupted surgery schedule. We asked the respondents to exhaustively rank all the disruptions on their frequency of occurrence and classified them into three broad categories (frequently, sometimes, rarely). About 96% of the respondents indicate to be at least sometimes confronted with the tardiness of a patient or a no-show (h). Such tardiness may result from, for instance, late arrivals of day-care patients or the lack of transporters to simultaneously provide patients to the operating rooms. We doubt, however, if this high percentage is substantially determined by the occurrence of no-shows, as only two hospitals could roughly indicate the yearly number of no-shows. For both hospitals, the percentage of no-shows was far less than 1% of their total surgical workload. Other important disruptions of

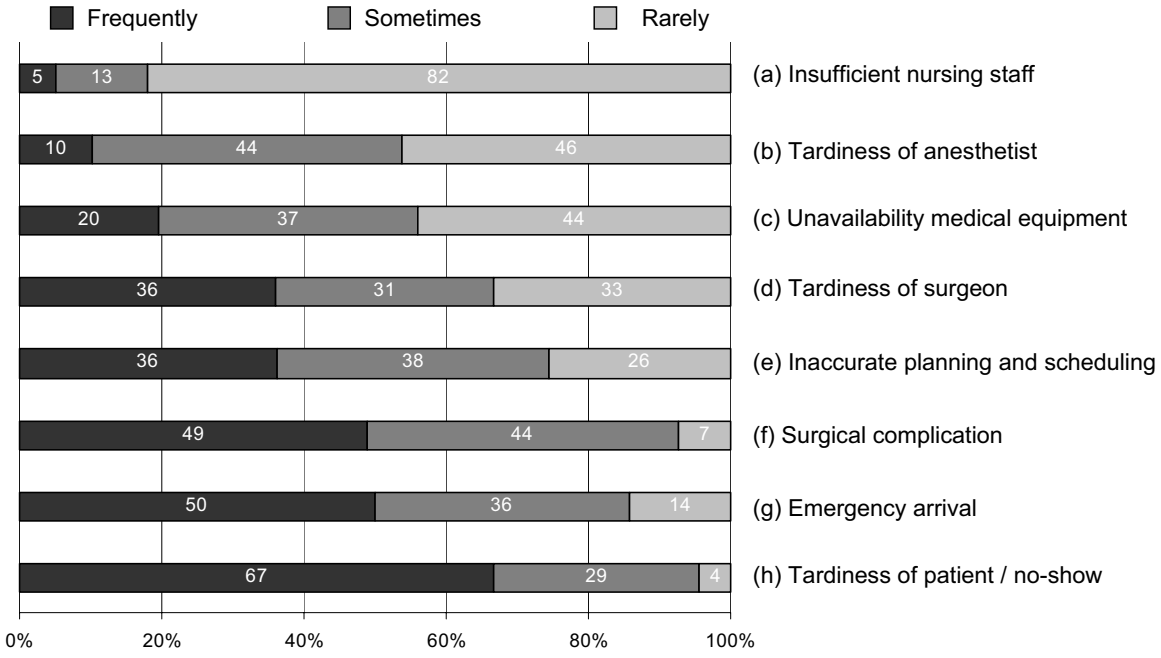

Figure 6: Overview and frequency of disruptions to the original surgery schedule

the surgery schedule, for instance, stem from complications during surgery (f) or the arrival of non-elective patients (g), i.e. the class of patients for whom a surgery is unexpected and hence needs to be performed urgently. Ironically, the planning of the operating theater seems to be a substantial cause of its own disruption (e). On the contrary, hospitals in Flanders do not seem to cope with a lack of nursing staff to perform surgeries (a), nor with the tardiness of the anesthetist (b).

Hospitals may react to the negative consequences of the disruptions by inducing some necessary changes to the surgery schedule, such as swaps of surgeries between operating rooms. The threshold to introduce such reactive scheduling policies, though, differs between hospitals. Figure 7 shows that about 9% of the respondents reactively adapt their surgery schedule for any kind of disruption that takes place (a). About 17% of the respondents indicate to adjust the planning when the disruption tends to affect multiple operating rooms (b), whereas 39% change their planning when the disruption would lead to operating room overtime at the end of the surgery day (c). A substantial amount of respondents (26%) report that disruptions do not necessarily trigger explicit rescheduling, as the impact may be anticipated by the surgeons or the anesthetists (d).

Since the arrival of non-elective patients was expected to be an important cause of surgery schedule deviations, we surveyed the hospitals on the way they deal with such arrivals. Surprisingly, only 39% of the respondents register the occurrence of non-elective patients in their information system or database. 57% of the respondents, on the contrary, do not register non-elective arrivals. About 4% of the hospitals in the response set did not express their opinion about this question. When considering non-elective arrivals, a distinction can be made between emergent patients (emergencies) and urgent patients (urgencies) based on the responsiveness to

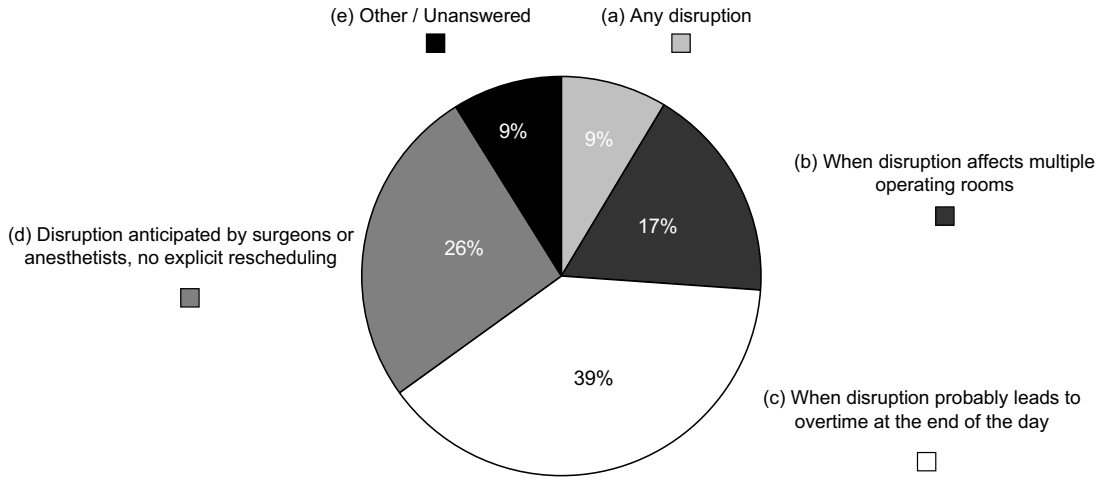

Figure 7: Degree of reactive scheduling in order to fix disrupted surgery schedules

the patient's arrival, i.e. the waiting time until the start of the surgery. Whereas the surgery of emergent patients has to be performed as soon as possible, urgent patients are sufficiently stable so that their surgery can possibly be postponed for a short period. With respect to the emergencies, 85% of the respondents report to perform the surgery in the operating room that is the first to be released (idle). Only 4% of the respondents indicate to intentionally reserve capacity for emergencies in advance. In particular, they provide one or multiple operating rooms that are only accessible to the emergent patients. Other opinions (4%) consist of, for instance, hospitals in which emergencies are performed in the first operating room that will be released, unless there is an operating room idle by accident (e.g. holiday of a surgeon). About 7% of the respondents left this question unanswered. With respect to the urgencies, two major practices are identified. Urgent surgeries are either performed at the end of the day, when the regular surgical program is finished (30%) or they are incorporated in the regular program of the appropriate discipline along the day (54%). The remaining part of the respondents (16%) indicates to combine both practices and makes a decision based on the specific discipline, surgeon, arrival

time and surgery schedule or did not provide any opinion.

Occasionally, multiple non-elective patients arrive approximately at the same time so that priorities have to be stated. Dexter et al. [5] report on three strategies to sequence non-elective patients. First, it is possible to perform the surgeries based on medical priority. Second, cases can be performed in the order that they arrived. Third, one may perform the surgeries in the sequence that minimizes the average length of time both surgeon and patient have to wait. We asked the hospitals to rank these three policies according to their importance and visualized the outcome in Figure 8. A vast majority of respondents (86%) consider the medical aspects (a) as the most important feature to determine priorities. About 68% of the respondents indicate that the arrival sequence (b) is the less important factor that should be considered for setting the priorities.

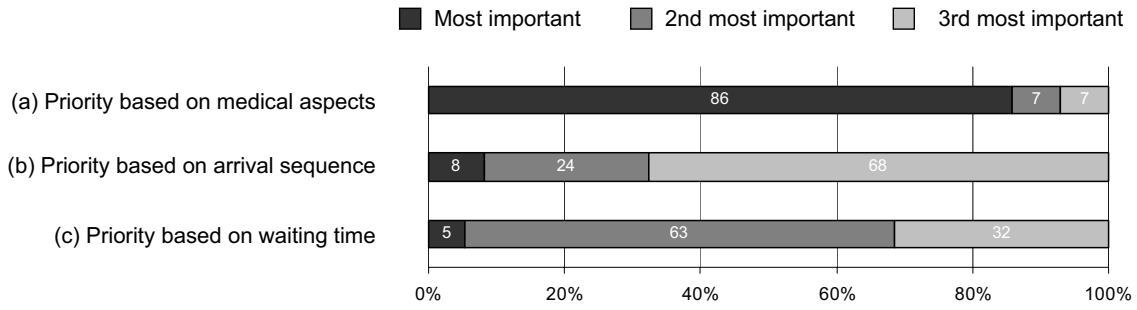

Figure 8: The importance of the medical aspect, arrival sequence and waiting time for setting priorities when multiple non-elective patients arrive simultaneously

4 Discussion

We noticed that the outcome of this survey largely corresponds to the results that were obtained by Gemmel and Bourgonjon [8], as they also targeted the hospitals in the Flemish region for their

questionnaire. We were able to compare certain aspects that were commonly addressed in both surveys, such as the opinions about objectives, disruptions, estimation of durations, policies to accommodate urgencies and emergencies, open scheduling versus (modified) block scheduling or the occurrence of various priority rules. Except for small deviations in the percentages, both surveys point at comparable general insights. On the one hand, this similarity implies that the opinions and practices that relate to the planning and scheduling of the operating theater in Flanders are quite stable over time. On the other hand, this resemblance can be interpreted as a validation of the results. The design of our survey, however, does not entirely coincide with the one of Gemmel and Bourgonjon [8]. We also questioned the hospitals for issues related to, for instance, the algorithmic support for constructing the planning, expansion of the operating room capacity or the threshold for rescheduling due to disruptions. As we already mentioned in Section 2, we also wanted to keep the questionnaire as brief as possible to improve the response rate. Therefore, we did only reproduce a limited set of questions that were addressed in [8].

For the remainder of this section, we try to interpret some of the most interesting findings that result from the survey and evaluate how the scientific research efforts relate to the evolutions that we encountered in practice. With respect to the objectives, we indicated that hospitals mainly strive to achieve a high utilization of the operating theater while they want to minimize the risk of overtime. Moreover, they seem to pay thorough attention to both the improvement of throughput and lead times (i.e. waiting time) and they try to incorporate various preferences of the medical staff. This set of objectives seems to be well addressed in the literature [4]. However, the application of planning and scheduling procedures does not only affect the performance criteria of the operating room itself, but also of its depending facilities, such as the post anesthesia care unit, the intensive care unit or the hospital wards. Although

the literature already provides many approaches that deal with these interrelated issues (e.g. [1], [13] or [14]), hospitals in Flanders do not yet seem to realize their importance. One reason for this void presumably lies in the inherent complexity that stems from the integration of the operating room with the other facilities in the hospital. Since the outcome of managerial measures in the operating room on these related facilities is difficult to predict for the human planner, advanced planning and scheduling techniques from the field of operations research and operations management are needed. We doubt if hospitals are currently aware of the power of these techniques, as more than half of the respondents clearly indicated to construct the surgery schedule manually. Without algorithmic support, evaluating the entire set of feasible solutions is virtually impossible and the opportunities to exploit the managerial power that stems from the operating theater are lost. In other words, optimization techniques may lead to an evaluation of a surgery schedule that is otherwise intractable for the human planner. In order to create this awareness amongst practitioners and further improve the flexibility and user-friendliness of the emerging applications, a closer cooperation is needed between the hospitals and the scientific community, which should act as a pioneer in advanced technologies.

The quality of computerized and mathematical methods, though, depends on the way they are developed and used in an analysis. We can easily illustrate this proposition by means of an example in which we try to estimate the expected duration of a specific type of surgery. We focus on a procedure type that relates to the diseases of the skin and subcutaneous tissue (ICD-9 classification: 680-709) and include about 300 observations of actual and estimated durations (of surgeons) that are obtained from an academic hospital in Belgium. In particular, we are interested in the average deviation between the actual and the estimated surgery duration. This deviation equals 46 minutes when surgeons are allowed to estimate the surgery duration, whereas

this deviation increases to 71 minutes when the estimated duration is set to the average based on the historical data. The estimation of the surgeons outperforms the mathematical average since the surgeons are able to differentiate even further between the patients of that particular class (e.g. based on age or slightly different intervention). However, when we group the patients with the same estimated duration (determined by the surgeon) and change for each subgroup the estimated duration to the corresponding mathematical average of the subgroup, we notice that the average deviation decreases to 35 minutes. It should thus be clear that the success of analytical and mathematical approaches depends on its implementation mode.

It is somehow disappointing to see that the hospitals in Flanders anticipate disruptions to the surgery schedule mainly in a reactive way, i.e. only dealing with problems when they actually occur. Instead, one could schedule in a proactive way and incorporate some expectations about disruptions during the construction of the surgery schedule. Think, for instance, about the arrival of non-elective patients. Although this type of disruption is definitively stochastic in nature, an expected daily amount of emergencies may be determined and an appropriate amount of operating room capacity may be reserved in advance for their treatment. Recall that only 4% of the respondents applied such a proactive scheduling policy. Although this spare capacity may be centralized in entire operating rooms, the responsiveness to emergencies is improved when this capacity is spread over the entire set of operating rooms [17]. One indispensable condition to generate proactive schedules, though, is the detailed registration of disruptions in a database. As indicated in Section 3.3, this prerequisite is currently lacking in Flanders' hospitals.

Today, the lack of nursing personnel is a widespread problem in hospitals. Although there seems to be a slight increase in supply, the shortage of nurses is still expected to be substantial in the future [2]. We already mentioned, however, that operating room scheduling may alleviate

the peak demands for nursing personnel needed in the hospital wards, post anesthesia care units or intensive care units. Surprisingly, the development of surgery schedules that achieve such leveling objectives does not seem to be a priority for the hospitals in Flanders (see Section 3.2). Moreover, the shortage of nurses does not seem to constitute a significant cause of disruptions to the surgery schedule (see Section 3.3). We believe that many respondents narrowed their view to the nursing personnel that assists during the surgery instead of including the nursing care that is needed immediately after the surgical act. Since medical staff and nursing personnel are costly resources, their use should definitively be planned in an efficient way.

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