Reducing waiting time for elective surgeries

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ABSTRACT

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Currently, the positioning of patients on elective surgical procedures wait lists is carried out through a decentralized approach involves a complex set of interactions between hospital capacities and patient demands in Quebec.

The primary goal of the research is to determine if a centralized vs. the present decentralized organizational system is beneficial for the patients, in such a manner that the priority on the waiting lists of patients is updated to reflect the amount of time they have waited. The current study combines quantitative computer simulations and qualitative interviews that help in the understanding and interpretation of the simulations' results. The qualitative and quantitative results are triangulated in order to provide better analysis of the results.

The qualitative portion of this examination, based on different literature reviews as well as on 12 interviews performed with the hospital's staff, aims at understanding the environment and what pressures the hospital staff face in their procedures to create the elective surgeries schedule. The results show that different surgical units within the same hospital have different methods to plan the surgical schedule.

The quantitative analysis is based on simulating a *centralized planning method* of elective surgeries planning for five different surgical units in order to provide different perspectives vis-à-vis the current *decentralized planning method*. The difference between the approaches is provided in order to obtain the best method that minimizes elective surgery waiting time, taking in consideration certain factors.

The results of the simulations show that centralization is beneficial for certain surgical units and for specific indicators, where decentralization is beneficial for other units and/or indicators. However, there is no definitive overall conclusion that centralization is better than decentralization or vice-versa.

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This thesis is dedicated to my grandfather, Nicolae Ancuta. Even though he is not with us anymore, I am certain that he knew that I will accomplish it. I know that I make him proud.

To my Grandfather,

and his ancestry and heritage for which I am more than grateful and proud

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RESEARCH QUESTION[1]

Having access to surgery is becoming a scare resource in Quebec as the waiting time for elective surgery (ES) increases. This is the case in many Quebec hospitals, in many European nations, but also for the hospitals in the United States of America. The hospital model (that is different from the *healthcare system*) is extremely similar in all these settings and the approach taken to schedule elective surgeries is almost analogous.[2]

There are many issues regarding the difficulties of the current surgical planning system due to its decentralization of many processes. The competency of the planning method must be validated. It is this aspect that the new proposed planning system is addressing. It should be noted that there are other designs that could provide different descriptions and analysis. The current research focuses only on the decentralization and centralization of certain decisions regarding the manner in which elective surgeries are planned and scheduled.

The research question that this study attempts to answer is: would a centralized elective schedule planning system provide better results for the primary stakeholders, the patients, regarding their surgery waiting time? Stated differently, would a centralized schedule planning method reduce the wait times for patients who are awaiting elective surgery?

In order to respond to the needed re-structuring of the organization, much research has been done on decentralization and centralization decision making structures of healthcare organizations without any clear conclusions. Both Weinman et al. (1979) and Mechanic (1973) point out that decentralization is present in community organizations, yet large mental health organizations are inclined to use centralization.

Surgery, having a very high status position, and operating time allocation are just part of the bigger hospital picture. Almost all surgical units in most hospitals behave in the same manner. This is so as 'it is the system', 'we must behave as others do in the system'. The latter mentality is erroneous and infringes on the needed benefits of the patients.

There are different types of implications resulting from this research. *Patient surgery wait time*: 'does centralization provide a shorter wait time in comparison with decentralization?' is the main question. Based on this, different structures might provide better results such as

[1] The use of the masculine includes the feminine gender as well.
[2] Information provided through different personal interviews with the professional staff of the hospital under study.

shorter average and maximum or better utilization of the Operating Room (OR) time (idle time and overtime). Another aspect that is important is if centralization/decentralization is applicable to all the surgical units or only to some of them. *Interactions between stakeholders*: having a better grasp of the interactions between surgeons, nurses and administrators, the study provides insight regarding what is important for each type of actor. Having a grasp of 'what' the differences between the centralized and decentralized decision-making are and 'why' they are present may help understand how the system behaves and how it can be improved. *Organizational structure*: if the hospital's higher administration desires to make certain changes in the process structures regarding the scheduling of elective surgeries, it has all the information needed, may it be qualitative or quantitative, to make an educated decision.

INTRODUCTION

In order to answer the research question, if a centralized planning system would be beneficial for the reduction of waiting time for elective surgeries (ES), the following qualitative and quantitative approaches are devised. A thorough literature review is taking in consideration, thus forming the theoretical framework. Interviews with different staff of a major hospital in the Montreal region are performed in order to understand the planning processes, and potential issues regarding the ESs planning. On the quantitative front, different simulations are performed that mimic a centralized planning system. The results of these optimization-simulations are then compared with historical values, where the latter are the base line of comparisons. Currently, the hospital is considered to use a decentralized method for surgery planning; therefore, the comparison between the two systems is a comparison between 3 centralized scenarios with the present decentralized elective ES. The analysis of this research falls under the auspices of decision-support and not under decision-making. Stated differently, the research is not predictive; it has elements that are combined in a descriptive and prescriptive mold of the current ES planning situation in Montreal.

The aim of the research is to analyze if a centralized planning system is more efficient and effective for patients who wait for their ES. In order to have a good understanding of the topic, different organizational theories are used in the analysis.

For 4 out of the 5 surgical units under study, a centralized structure provides a shorter average waiting time for patients in comparison with the decentralized system. Yet, for the one

unit where the latter configuration is beneficial, the difference in the average wait time with the next best option (Scenario 1 Centralization) is only 3 days. Considering OR overtime, overall, centralization of decision making provides better results, yet different scenarios are better for different units. Regarding idle time, the historical values are better than any centralized scenario. It must be noted that the difference between some of the values is marginal.

The overall simulations' results show that centralization is beneficial for certain surgical units and for specific indicators, whereas decentralization is also beneficial for other units and/or indicators. There is no definitive overall conclusion that centralization is better than decentralization or vice-versa. Each organizational structure works well in specific environments, under certain contingencies.

The proposed research focuses on a potential reduction of ES waiting time in a major general hospital of Montreal, Quebec. Some of the recommendations and insights achieved by this study can be applied by different hospitals that use the same type of ES schedule planning.

The analysis only takes in consideration elective surgeries and some of its components: patients, surgeons, nurses, administrators, five surgical units, OR allocation (space and time). The interactions between the stakeholders (surgeons, nurses, hospital administrators, patients) are highly dynamic and very complex.

Broome (1999, p. 2) states that "… the scarcity of resources forces a society to weigh up alternative possible uses for these resources…" In this statement, Broome underlines a few ideas. The 'scarcity of resources' are the natural/environmental imposed situations. 'Weigh(ing) alternative possible uses' is the descriptive and understanding of aspects of the world. Organizations are required to change because some resources become rare and/or they become more important than others. Healthcare centers are no exception. As previously mentioned, access to surgery is a scare resource in Quebec, and Canada. Table 1 provides the waiting time benchmark and the percentage of cases completed within the benchmark; Table 2 shows sample figures regarding some surgeries performed in 2000 and 2009 in Canada.

Priority clinical area	Hip replacement	Knee replacement	Hip fracture repair	Cataract removal	Cardiac surgery	Radiation therapy
Benchmark wait time	*26 weeks*	*26 weeks*	*24 hours*	*16 weeks*	*2 to 26 weeks*	*4 weeks*
Jurisdiction	Score					
All Canada	84	79	78	83	99	98
British Columbia	85	76	80	79	99	92
Alberta	78	69	81	48	95	94
Saskatchewan	69	60	72	62	100	97
Manitoba	63	57	82	70	99	100
Ontario	91	89	77	88	100	97
Quebec	88	83	[1]	87	[3]	98
New Brunswick	79	67	78	89	100	87
Nova Scotia	57	42	78	67	100	85
Prince Edward Island	90	73	74	80	[4]	97
Newfoundland & Labrador	75	67	[2]	80	100	94

1. Quebec hip fracture repair data is not comparable to other jurisdictions.
2. Newfoundland & Labrador hip fracture repair data is not comparable to other jurisdictions.
3. Quebec cardiac bypass data is not comparable to other jurisdictions.
4. Prince Edward Island does not provide this cardiac surgery; patients receive care in other provinces.

Table 1: Percentage of patients receiving care in priority areas, Canada, 2010*

* McGurran 2013, p. 107

Surgical procedures by ICD-9-CM	2000	2009	% change in procedures between 2000 and 2009
Cataract surgery:			
In-patient	13.2	4	-69.60
Day-case	731.8	1 048.3	43.20
Tonsillectomy with or without adenoidectomy:			
In-patient	44.4	24.5	-44.80
Day-case	106	75.7	-28.50
Percutaneous coronary interventions (PTCA and stenting): in-patient	108.7	130.2	19.70
Coronary bypass: in-patient	76.5	60.5	-20.90
Appendectomy: in-patient	104.1	101.1	-2.80
Cholecystectomy:			
In-patient	152.7	82.8	-45.70
Day-case	96.5	125.4	29.90
Laparoscopic cholecystectomy:			
In-patient	121.4	69.6	-42.60
Day-case	95.4	122.6	28.50
Inguinal and femoral hernia:			
In-patient	75.1	51.7	-31.10
Day-case	139.4	145	4
Hip replacement: in-patient	79.1	123.5	56.10
Knee replacement: in-patient	73.2	144.1	96.80

Table 2: Procedures per 100,000 population (in-patient and day cases), Canada, 2000 and 2009*

* McGurran 2013, p. 102

It must be mentioned that this study only examines the OR schedule. It is not concerned with available beds in the ICU (after the surgery; in reality, if ICU beds are not available, a specific surgery will not be performed, making the availability of beds the bottleneck), OR resource availability (instruments, technical devices, etc.), staff availability, and many others. Even if this is the case, coordination still plays an important role in this study as the planning of surgeries is dependent on other surgeries, OR availability, available time for surgeries of different surgical units. Regarding the team coordination, it is not referring to the coordination of the surgical team in the OR, but to the coordination between surgeons-nurses-administrator in order to schedule a surgery. Furthermore, the performance of the actual surgeries, what happens in the OR or the outcome of the surgeries, is not considered in this study. The major focus of the analysis is what happens before people enter the OR; in other words, how a surgery got scheduled 'in comparison' to another surgery and how the schedule gets built.

Due to the complex nature of legal framework involved in hospital management, healthcare institutions have adopted some altered management practices and tools, according Lega and DePietro (2005). Consequently, the models can be broadly categorized in two different spectrums, namely the American and Anglo-Saxon model and the European heath system. The first model is defined by the role of physicians, who are paid a fee-for-services basis, managing the hospital resources such as beds, operating theatres, and technological equipment. In this model, the administrative department oversees nurses and other staff members. These are characterized by a financially aligned culture of the entire organization. Lega and DePietro (2005) label this model a 'two-headed hospital' as it consists of two distinct hierarchical structures: one for the physicians, and the other for the remaining staff members.

On the other hand, the European heath model is characterized by physicians on the hospital's payroll, and resources are allocated by the top management to the respective units. This particular system is a centralized system, where the Chief of each unit, the medical professional, is responsible for the access and distribution of the collective resources. Hence, it is also known as a 'single-headed hospital', where the resources are evenly assigned throughout the hospital in a top-down manner.

There are proponents that have a tendency to bureaucratize the health institution in order to have fair distribution of resources and accountability over the latter, and opposing this, there is the professionals' thirst for autonomy in their medical practice.

In his analysis, Litwak (1961) points out that there are two different systems implemented: medical and administrative. The reason why these different structures work in tandem in Litwak's (1961) study is that a pre-allocated distribution of authority is presented, imposed, and accepted by the employees; this means that the actors, their roles, responsibilities, and duties are clearly predetermined and stated. In different words, all know where they stand and what their duties are: the allocation of authority and its distribution were already institutionalized, and accepted by all those involved, concerned and affected by it. To this, "there was little conflict between the two systems because management and workers had agreed in advance that interaction between one set of roles was to be handled by local discretion, but between another set of roles by centralized authority. Since the roles were clearly differentiated, it was possible to do this with minimal friction" (Litwak 1961, p. 183).

For the purposes of this research, the hospital staff is divided in physicians, nursing staff and administrators; they form the triad forces (see Figure 1) in a hospital. It is the interactions between these groups, and their consequences that this research attempts to unravel. Even though there are some tensions between the triad forces, these are interactions that are worth mentioning as they are important and extremely dynamic. Eakin (1984, p. 222) illustrates very well the different lack of authority between two of the triad members:

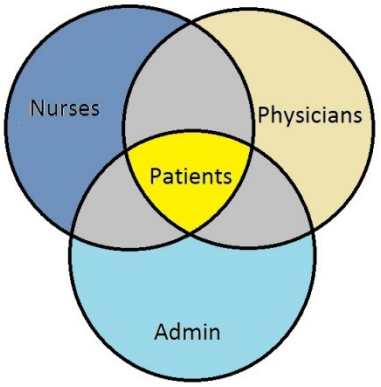


Figure 1: The triad forces

> Administrators have the advantages of bureaucratic authority, administrative skills, and strategic organizational location, but their power is limited by their lack of 'line' control over physicians and by their accountability to the board of directors. Similarly, the power of physicians is enhanced by their professional claims on clinical autonomy, but is constrained by their dependence on the hospital and by its budgetary and organizational restrictions.

An important aspect to consider is that as hospitals grew their complexity also grew. Kingston (1983, p. 1165) is concerned about a very drastic element: "forces exist which move hospitals away from a patient-care focus. Wilson (1982) has pointed to three systemic pressures: the preoccupation with resources and budgeting; the pressure for public accountability; and the demands for long-term planning in the face of changing governmental, especially financial,

regulation." One realizes that these pressures have an important role to play in the proper administration of a hospital.

Sustainable healthcare ensures the delivery of better services while having minimal costs, it does not negatively impact other population systems (Schroeder et al., 2013), and minimizing waste. According to Schroeder et al. (2013, p. 183), there is "no such thing called as waste, there are only 'wasted resources'". Radnor et al. (2012) point out that in healthcare, *waiting* is a waste as it relates to the waiting of the patient for its surgery. Furthermore, according to lean literature, underutilization rates for the OR is also considered a wasted resource as having a dedicated OR but no surgeries performed increases the costs for the hospital. Lean aims to optimize the usage of resources. Lean can be considered as the process of reconfiguring organizational mechanisms in hopes to reducing wastage, increasing efficiency and a culture of progressive improvement (Womack and Jones, 1996).

Lean projects in healthcare are becoming increasingly widespread (Brandao de Souza, 2009). His particular research highlights that the U.S. is the front-runner in this aspect, with approximately 57% lean projects, U.K. with 29%, and Australia with a nominal share of 4%. Cases such as the Virginia Mason Medical Center in Seattle (U.S.), Flinders in Australia and the Royal Bolton NHS Foundation Trust in the U.K. have become eminent examples of lean implementation in medical care institutions. In the cases mentioned above, and countless others, it is apparent that these projects have tremendous potential in terms of reducing cost and waste, enhancing efficiency of the organization and implementing dynamic and effective systems. Lean projects also offer some intangible benefits, which include greater employee morale and better patient satisfaction (Radnor and Boaden, 2008).

According to the Canadian Institute for Health Information (2012), the total health expenditure in Canada, in current dollars, was $193.1 billion in 2010 (representing 11.9% of the Gross Domestic Product (GDP)), and it was forecasted to reach $200.6 billion in 2011 and $207.4 billion in 2012. In 2002–2003, the operating rooms represented 5.9% of the hospital budgets in Canada, and in 2011, Canadian hospitals accounted for 29.1% ($58.4 billion) of national expenditure on health care, or about 3.4% of the 2011 GDP. It is due to these expenditures and their increase in the next years that new ways to enhance efficiency and sustainability are undertaken as one of the major priorities in Canada regarding hospitals (and healthcare in general) is the reduction of costs.

Even though ORs are the hospital's largest cost center, they are also the greatest source of revenue. As surgeries can cost between 9% and 15% of any hospital's annual budget which is provided by the different governments (federal and provincial)[3], reducing the underutilization and overutilization of the OR has managerial, financial and operational implications in any hospital. This can only be accomplished with better *scheduling* planning, which is dependent on proper time estimation of the surgeries (duration), as well as their arrangement for the OR (sequencing). In other words, a cost effective OR can be achieved by shorter surgical durations, rational scheduling of various types of surgeries, and minimization of the non-operative time by reorganizing OR activities (Azari-Rad et al., 2013).

Having a lean approach to the scheduling of elective surgeries would ensure that resources are utilized properly and that waste does not accumulate. As mentioned before, waste refers to wasted time, but also to all the unnecessary interactions between units and actors in order to come to the best schedule possible. All these interactions form an open system where informal dynamics are present. Furthermore, every actor and every unit involved in the OR or OR scheduling has its own goals to achieve.

Albeit there being rapid medical and technological advances, the social aspects and relationships between the actors present in the hospital were and are extremely slow to develop. For this reason, one can state that the social organization of the hospital is lacking the social verve and vigor which characterizes the corporate world. Wilson (1963, p. 74) describes well two possible reasons why the hospital as an institution is so 'special':

> … the hospital grew in haphazard fashion. It is probably the last major institutional complex in the modern West to accede to the bureaucratic patterning of work which has long characterized government, big industry, and other large organizations. There are two persistent reasons why the hospital can perhaps never approach the degree of formal controllability, of symmetrical power and task arrangements, which distinguishes industry and government. One is the nature of the work flow, the temporal and ethical constraints imposed by intractable human material: the patient. The other is the nature of the medical profession, which resists bureaucratization and is the unchanging repository of certain fundamental decisions about the care of the ill.

Building on previous research, Kingston (1983, p. 1161) believes that "one explanation of the poor implementation of organizational research studies may therefore be a soggy,

[3] Information provided through different personal interviews with the professional staff of a Montreal's major general hospital.

confused or incompetent client organization: the hospital itself." Even if from the outside, one can see the hospital as a unitary actor, it is very hard to actually pinpoint to what type of actor it is as well as who is responsible/accountable: the board, the administrator, the physicians, the nurses, the patients? The correct answer is actually 'it depends' on what a researcher is looking for, as the hospital is a conglomerate actor.

This study is descriptive and exploratory and, to a certain extent, prescriptive. The first step is to comprehend in detail the reasons how and why the hospital works regarding ES planning. However, before full insight can be achieved, one must understand the main reasons why the hospital structures are configured in the manner in which they are. Once the theoretical aspects are uncovered, empirical exploration of the main interactions between stakeholders and units is carried out using data from direct interviews with some principal players within a major General Hospital of the Montreal region. The prescriptive aspect of the research is characterized by performing different computer simulations of a hypothesized *centralized* ES schedule planning. The results are compared with the historical data of the *decentralized* ES schedule planning.

This research is organized in the following manner. The literature review is firstly concerned by a managerial perspective in a specific setting, which also describes the hospital's administration realm and the different hierarches present, but also by the need for coordination between the different stakeholders. Moreover, in order to funnel the research, different centralization and decentralization structures are analyzed within the context of a hospital. These different structures are important as they determine distinct resource allocation methods. This gives rise to the main setups of organization, of which in this case, are based on a bureaucratic approach. Bureaucracy plays an important role in any hospital; however, because the hospital is a specialized institution, which caters potential conflicts between different power structures and power plays of the actors involved, the professional bureaucracy is also studied. Even if the hospital is a bureaucratic organization, as different professional groups are vividly present and affect the manner in which surgeries are planned based on their goals, the social factors and differences that affect the interactions between some of the professional groups are also studied.

Regarding the qualitative portion of the research, there were 12 interviews that were performed with different professional staff of the hospital. The interviews are analyzed by

surgical unit, by different groups of professionals and their input regarding a potential centralization of the elective surgeries booking.

On the quantitative side, different computer simulations models were performed. The data provided by the latter is analyzed using different indicators; however, the main variable which this research focuses on is the average waiting time of patients for their ES.

Furthermore, the results of the simulation are combined with the information provided by the interviews of the hospital's staff. A comparison between the different five surgical units under study is also provided.

ORGANIZATIONS

Daft (1991) maintains that organizational design refers to the assigning of tasks to certain individuals and sub-units within an organization, representing responsibilities, authority levels, degrees of control, and hierarchy. It is this design that is the key factor in the efficiency of the organization. Building on Davis and Marquis (2005), important economic and social inquiries for the current study can be answered by institutional theory and organization theories as the former greatly influence the outcomes/procedures that can be seen in organizations.

In today's economic environment, competition is fierce and organizations need to adopt changes in order to adapt, to be more agile, to secure resources, simply put, to be in business tomorrow. Healthcare centers are no exception. Every organization must look to accomplish the following tasks, as per Perrow's (1961, p. 856) research:

1) "Secure inputs in the form of capital sufficient to establish itself, operate, and expand as the need arises;
2) Secure acceptance in the form of basic legitimization of activity;
3) Marshal the necessary skills;
4) Coordinate the activities of its members, and the relations of the organization with other organizations and with clients or consumers."

It must be noted that these four items are not likely to be equally important at any point in time.

In the multi-level, multi-dimension organization, there are multiple legitimatization rationalities. Taking in consideration Scott's (1995, p. 140) observation that "institutional rules invent rationality" and legitimize it, different questions need to be considered: how are conflicts

resolved between the primary stakeholders; how do these conflicts arise, taking in consideration that they are caused by institutional rationalities; and, what are those institutional rationalities.

In their article about typology and measures used for studying professional and administrative organizational models, Bunderson et al. (2000) introduce four models of organizations: the bureaucratic system model, the market enterprise model, the professional group model, and the community service model. These models are distinguished by internal and external division of managerial and professional logics. The information received from the authors' survey shows that these models and their constructs are generalizable across all occupational groups and are stable across time, providing valuable tools in the analysis of complex organizations.

Bunderson et al. (2000) found that administrative and professional perspectives can take both internal and external forms. The distinction between the four organizational models recognizes different characteristics of these models as some deal with issues of internal coordination, and others are related to the matters of external adaptation. Depending on which issues are more vital, this can mean different approaches to organizational goals, functions and rules (Miller, 1992; Perrow, 1961; Quinn and Rohrbaugh, 1983). The authors explain how their organizing models compare to internal and external divisions of professional and administrative models:

> The bureaucratic system model (administrative internal) views the organization as an efficient and coordinated system organized to pursue common goals. The market enterprise model (administrative external) views the organization as a business enterprise organized for competitiveness and wealth maximization. The professional group model (professional internal) views the organization as a collegial society organized to promote consistency and quality in the work of a particular occupation. Finally, the community service model (professional external) views the organization as a foundation organized to apply professional expertise for the benefit of the larger community or society. (Bunderson et al. 2000, p. 369)

Bunderson et al. (2000, p. 366) notice that professional models highlight authority which is based on "technical competence, commitment to the work, collegial decision making, and a service orientation". On the other hand, administrative models stress authority based on the duties of a legally defined office, as well as commitment to the organization, hierarchically based decision making and orientation towards efficiency (Gouldner, 1957; Parsons, 1947; Van Maanen and Barley, 1984). With the rise of the percentage of workforce involved in professional

and technical work, tension between these models and between the people belonging to different 'systems' becomes an important element in the increasing number of organizations.

The market enterprise model according to Bunderson et al. (2000) perceives the organization as a business, a corporation, which is organized for competing, growth and accumulation of wealth. This model represents the external element of administrative rationale. In the market enterprise model an organization needs to compete more efficiently than the other businesses and tries to satisfy the consumer. The model is highly dependent on the market demand, and organizations adapt their supply accordingly. The consumer is the one in control, not the employees or managers. Everything inside the organization, from what and how work is performed, to the products/services and their value, is in function of the market demand. Therefore, it is characterized by a lean pull-system, and it requires flexibility towards the consumers' demands.

The community service model is based on a view that the organization is a foundation, created to apply professional knowledge and expertise for the greater good, that is, for the benefit of society as a whole (Bunderson et al., 2000). This model advocates serving the community for a simple reason – it is the just thing to do. It represents the external orientation of the professional approach. Altruism and serving the community conquers egoism, the self-interest, profit and efficiency. The idea is to encourage professionals to recognize their personal and social obligations and rely on them, rather than on their performance. "In this way, professionalism not only becomes a cultural template for organizing work but also becomes a valued cultural resource for society (Barley and Tolbert 1991, p. 5)" (Bunderson et al. 2000).

The bureaucratic system model perceives an organization as a system which is organized to persist on achieving common goals that are planned and ordered by legally appointed officials. It spreads out work from person to person, from unit to unit, and then integrates this work in the most efficient way. This is achieved by division of labor, hierarchy, specialization for performing specific tasks and finally, a clear distinction of official duties and personal interests. Integration can only be attained if there is universality and formality, and if rules and policies are enforced. Rights and duties of each position are specified by abstract rules, and recruitment and promotion are regulated by a special administrative staff. Bunderson et al. (2000) have the same approach regarding this model as the Weber's bureaucracy.

The professional group model views an organization as a society of colleges, who are assembled to ensure consistency and quality in their profession and to support these professionals in their work. The notion here is that only people who possess adequate knowledge and skills can decide about members of the group and how their work should be done and evaluated. Thus, professionals seek to build their organizations in such a way that allows them to preserve their control over their work and to judge what is best for their clients. For these reasons, the professional groups can be understood as guilds.

Having the same rationale as Bunderson et al. (2000), Comstock and Scott (1977) find it obvious that different types of work require different types of organizations. Routine work benefits from bureaucratic organizations, while work that is less predictive is done more effectively in the flexible, less hierarchical surrounding.

Furthermore, there are three other models that can explain how an organization could be structured. These are very well described by Litwak (1961, p. 177):

> *Weber's model* is most efficient when the organization deals primarily with uniform events and with occupations stressing traditional areas of knowledge rather than social skills. The *human-relations model* will be most efficient for dealing with events which are not uniform (research, medical treatment, graduate training, designing) and with occupations emphasizing social skills as technical aspects of the job (as that of psychiatric social worker, salesman if there is little differentiation in the products, and politician). […….] Since they are conflicting, what characterizes this third model [*professional model*] and distinguishes it from the other two is a need for 'mechanisms of segregation'. These permit mutually antagonistic social forms to exist side by side in the same organization without ruinous friction. [Emphasis in original]

In today's hospitals, all these three models are present at the same time and work in parallel, aside from other micro and meso levels of interactions. This also adds to the complexity of understanding this institution. It is one of the main reasons why the analysis of the hospital as a unitary actor is so complex and not many researchers venture in examining it.

The uniform event has the following characteristics: the same assignment is frequent, and it is important. Usually, it is performed by highly skilled workforce (i.e., doctor/surgeon, research scientist, soldier in combat) in an environment that is constantly changing; adaptation is required. There are no standardized problems/circumstances such as in the case of an administrator of a utility company under pre-established guidelines, a soldier in peacetime, a line manager of an assembly line (Litwak, 1961).

Having non-uniform events in a hospital setting, one must take into consideration the socialization and interaction aspects of the actors involved. Although medical or technological advancements are made, these are still being implemented by humans, demanding thus that the *human aspect* cannot be ignored. Furthermore, Litwak (1961) also believes that non-uniform events will increase in future organizations. There are constant social changes as the actors learn and adapt to technology and the social interactions are in constant flux.

Even though there are variations within each sub-group, the main structures in which organizations are setup are the following: functional – organized around the resources available; divisional – organized around the outputs of the firm; and, matrix – organizations organized around both inputs and outputs. Hospital managers are quite fond of the matrix structure, which allows them to sync their main objectives, because:

i. it avoids wasting resources through duplication; utilization of the resources in the most efficient manner;
ii. it provides the highest level of patient-care, thus maintaining and increasing the hospital's image.

Yet, there are also weaknesses in a matrix organization, such as: double authority line (which is a source of potential conflict); it is slow in coordination of efforts; it may be unstable; it is costly (Creteur and Pochet, 2003).

Different types of healthcare institutions are organized in different manners in order to offer the services required to their constituents. The general hospital provides the most complicated structure as it is supposed to tender to a multitude of stakeholders. Due to the latters' different goals and requirements, the general hospital needs to use all the previously mentioned models: market enterprise, community service, bureaucratic system and the different professional groups' segregation. It is under the umbrella provided by the combination of these models that the hospital under study operates.

It is easy to see that the management, and especially the coordination, of all the resources required for the proper administration of such an institution can include certain pitfalls and difficulties.

Management

A properly run hospital must have an equilibrium and all the actors must accept that without all the pieces, representing all the actors, any hospital will not function properly. The most drastic consequence of a poorly run hospital is its closure, an effect that is felt by all those who work in the specific hospital. To a certain extent, paradoxically, it is the administrator who is supposed to implement and enforce it. Kingston (1983, p. 1159) also concurs with this idea as he states that "organization is about the regulation of human behavior for social purposes. It therefore mediates between policy (social purposes) and the delivery of health care to patients (human behavior). Rather, it is a framework constructed out of values, both individual and social, which should facilitate the work to be done."

Organization theory has evolved to a point where there seems to be a best line of action for any circumstances or events, and the evolution of organizational theory has reached a superior state (Kast and Rosenzweig, 1974). Many researchers, including Aldrich (1975), believe that the evolution of organizational theory is based on environmental fit, and so, the correct combination of environment states and organizational behavior will align perfectly to produce enhanced results, falling thus under contingency theory.

Consequently, management can become a computational activity if the manager is more interested to controlling the destiny of the company, which is in fact the best case scenario (Bourgeois, 1984). The rationale for this is that circumstances hinge on environmental, human and technical factors, all reducing significantly the choice-element from the manager's job. Worst case scenario could be that it becomes more of a waiting game, demanding reactive actions from the manager. It may be strongly argued that these particular thoughts are indispensable for empirical research purposes; however, their reductionism eradicates the fundamental characteristics of strategic management, eventually obstructing the academic growth prospects of the discipline of strategic management.

The real purpose and need for management in hospitals and healthcare institutions is not just to cut costs and govern things smoothly, but to improve the level of health and medical care being provided to the patients. For this purpose, enhancement of access to medical care is as vital as any role that the manager may have (Sheps, 1972).

At the same time, Chervenak and McCullough (2001) maintain that the primary focus of management has always been to protect and improve the economic interests of the organization

by utilizing leadership skills and experience. Traditionally, insurance companies have unlimited funds, and so the job of the manager had little significance in the economic aspects; this results in the selection process of the administrative staff requiring fewer skills. After the advent of the many forms of managed-care, alterations in the medical care reimbursements, and others, the management skills required to succeed as a physician-leader has risen exponentially. Conventional management styles that had been successful in the past are increasingly likely to fail in today's world of quality and cost management. Furthermore, Hall (1972) explains that the autocratic leadership is better suited for the "highly formalized, routinized, and centralized, that is, a mechanical type of organization" (Hage and Dewar 1973, p. 280-281) and that the persuasive/supportive leadership is more appropriate in "a decentralized, fluid, innovative, or organic type of organization."

In the 1990s, the change in governance of healthcare systems has supported the employment of industrial means of managing resources and personnel, sometimes encroaching upon the boundaries of clinicians and doctors (Beardwood et al., 1999). The new method of management tends to focus on realizing the objectives of the firm, at the same time evaluating the performances of the staff, including the physicians. It can be said that a specialized domain is incorporated in the medical care institution, where stress is laid on the administration to protect the institution, and enhance the performance that includes providing quality care and restricting wastage of funds (Campbell, 1994; Choiniere, 1993; Kelly, 1991; Nettleton, 1995). A separate perspective on this narrative is the fact that whether the new management procedure is indeed appropriate and necessary, as the professional effectiveness of the physicians is complicated to quantify in terms of cost.

Mauksch (1973) state that there is an assumption that the performance and output of the hospital is seen as the direct responsibility of management, and it attests to the skill and talent of the professionals associated with the organization. This particular assertion can be misleading, and most people believe that patient care is sometimes independent of the quality of administration. Numerous organizational factors are involved in forming a protocol within an organization, and often factors beyond control are introduced as variables, making it increasingly difficult to judge the quality of administration and healthcare being provided to the patients. The net effect is the interaction of various contributing factors, including roles, tasks, systems,

structures, ideologies, class-distribution, moral ethics, competence, etc. To pin-point a certain element in isolation can be hypocritical and misleading.

It is hard to understand why hospitals are not being controlled by the medical staff, especially considering the complexity of their jobs, specialized skill set, strong professional background and the power of organized medicine (Perrow, 1961). Physicians are afforded a certain prestige and status, and they are structured in such a way to be easily managed (by another doctor). A hospital is organized based on hierarchy and bureaucracy consisting of different committees and boards who decide rewards and sanctions. Since physicians are the ones who perform both staff and line functions, it is foremost their 'right' to have a say in the control of the affairs. Finally, doctors have an economic interest in the functionality of a hospital, as this not only advances their career, but also helps their private practice. Hence, a case can be made for doctors to have control over hospital affairs governance as they possess the knowledge and skills in order to prosper as professionals. In some cases, doctors are given the liberty to exercise complete control over their fields, and thus the role of the administrator becomes that of a superintendent. Nonetheless, in this case, the administration's stance may be overlooked and the long term objectives of the institution ignored. More often than not, this superintendent type of administrator position is fulfilled by a nurse.

It is easy to acknowledge that the hospital as an institution is greatly different in comparison with any other organization type. For this reason, the proper management – including the leadership component – of any hospital must ensure that the hospital responds to the needs of all its stakeholders, which are very diverse and that have in many cases, contradictory goals. Thus, the administration of a hospital is tasked to provide, as best as it can, the tools, devices and means to accomplish specific objectives.

However, one of the reasons why 'hospital administration' is so difficult to analyze, in Wilson's (1963, p. 68) perspective, is that "the human being who is educated or healed is not a thing but a process, and it is difficult to point to him as the concrete output of a work pattern." It is very hard to point to the 'patient-product'; the hospital does not manufacture anything per se. It is 'in the business' of providing specialized services since the hospital is characterized as part of the service industry. Furthermore, coordination is one of the most important aspects in today's general hospital because there are various professionals with various duties within various

departments. The coordination duty falls to the administrator who must take in consideration challenges to authority, and make sure that the entire system works well and is synchronized.

Furthermore, different fields require different perspectives in their analysis. According to Becker and Stafford (1967), the economists are more concerned with the profitability of the organization, market position and size of the market it captures. On the other hand, sociologists tend to focus on the administrative size, room for innovation, formal and informal structure, bureaucratization, etc. The psychologist however, restricts his examination to the inter-group and intra-group interactions, which take place within any organization.

An increase of the size of the hospital, and thus of the administration elements of the latter, require a multifaceted system of interactions and communications between different levels of the hospital (Anderson and Warkov, 1961). Furthermore, in today's general hospital the coordination activities also become more essential and intricate, thus requiring the administration component to be even more complex and more focused on the necessary elements.

Building on Wilson's (1963) idea that the physician is a 'guest' of the organization, this is still valid today for different reasons. One of them is that the physicians are not employees of the hospital: they provide their cases/patients seen directly to the government, which the latter provides the hospital with the funds in order to pay them. Furthermore, a physician can actually be tied to different hospitals, depending on his availabilities as well as those of the hospitals' or clinics'. There are no direct ties that link the physician to Hospital X as an institution per se. The hospital is just the provider of facilities where the physician performs his duties. Thus, the two main elements of the hospital organization (the patient and the physician) are just temporarily attached to the physical aspects of the hospital: the building. This is another reason why the administration of a hospital has difficulty in addressing certain issues with the physicians. As the latter are not direct employees of the institution, there are no penalties that the administrator can impose if the former do not apply the rules of the organization; thus, physicians have a free-wild-card where only in extreme abuse cases (power, status, medical) are penalized by the *Collège des médecins du Québec* (in Quebec).

One can notice that there is a trend, even more pronounced today, that administration is gaining territory in the hospital, power and prestige wise, fact that McKee (1970) already acknowledged noticing the social structure changes that took place since 1955. The hospital administrative 'profession' is rather new as it is only from 1946 that it became prevalent when

formal training started (McKee 1970, p. 26), and its beginnings were slow. In the U.S., the same characteristics were still present during 1970s, where only 21 educational institutions graduated around 200 people for this essential 'profession' (McKee 1970, p. 28). Today, the situation is better, however the hospital administration as a recognized field still lacks in its reputation.

Being a new specialty, administration does not have the same status and respect as its medical counterparts. The expansion of the administration's tasks and obligations in today's hospital pushes towards a professional administration.

It can be rightfully argued that because there are different stakeholders within the hospital, each with their own level of authority and each with direct control over certain specific resources, a hierarchy is created.

Freidson (1978) maintains that one of the main concerns of academic-hospital-state institution is initializing administrative, legal and economic structures in order to manage and coordinate the health services distribution and quality, within a financial mindset. Those who provide the services – physicians, nurses, technicians – are considered a different segment that is pushed towards 'nominal bureaucratization' (Freidson 1978, p. 979). Due to the divisions' functional and hierarchical setups, different occupations compete for authority and legitimization within and between their jurisdictions. Physicians oversee the primary service providers. Due to their 'position', the physicians are tasked with assigning duties, and overseeing the health services provided within the hospitals. Furthermore, the specialists, such as dentists, chiropractors, podiatrists, OR nurses, are also a separate segment, autonomous in their own right. This is one of the reasons why it is critical to set boundaries when it comes to observing groups (Borgatti and Halgin, 2011). Furthermore, although the unit managers and administration personnel are most likely to be physicians themselves, they nonetheless represent a completely different segment within the stratum of the health care profession (Freidson, 1978).

Litwak (1961, p. 178.) believes that "permitting each individual to control decisions on the job indicates a trend toward a colleague rather than a hierarchical relationship." This is what is supposed to happen in a regular, normal institution under normal and fair play circumstances. However, the hospital is all but that. There are different hierarchies present in the general hospital, and some units are able to control certain decisions. Permitting limited control over particular decisions makes sense from a medical perspective, as for example, the cardiology unit cannot interfere in another unit, or vice versa. However, this is just a segregation of expertise,

similar to the Weberian model or the professional model previously mentioned. Litwak (1961, p. 181) acknowledges this when he states that "hierarchical relations may well lead to efficiency when the job is defined by traditional areas of knowledge."

Eakin (1984) illustrates very well the different authorities (or lack thereof) between and of the triad members stating that the administrator of a medical unit has certain bureaucratic authority and administrative skills, yet these are limited by the control of the administrator over the physicians and nurses; the physicians have legitimacy over the medical decisions and clinical authority, but they are limited by their accountability to the hospital and formal organizations outside the hospital (*Collège des médecins*), and dependent by the resources of the hospital (e.g., access to the OR); nurses are also reliant on the resources of the hospital, controlled by administration, and obeying the orders of the physicians regarding the treatment recommended by the latter for individual patients.

March and Simon (1958) are of the opinion that the purpose of a hierarchy within an organization is to pass the organizational goals across the staff members in such a manner that their behaviors are governed by the objectives set by top management.

McKee (1970) suggested that dual accountability (clinical and administrative) can be implemented as a system, ultimately helping patient care, by providing various checks and balances as in Litwak's (1961) study. In this particular scenario, the administrator is tasked by keeping the physicians, nurses, clinicians, and technicians in line, and to resolve the conflict in the best possible manner to maintain the efficiency of a unit.

Furthermore, there are two very important aspects that can be considered the roots of the struggle between these two professional classes, nurses and physicians:

1) "the fantasy of medicine and the idealization of the physician", described by Peeples and Francis (1968, p. 35) as "the work of physicians tend to be regarded by laymen … as a glamorous drama in which physicians lead a grand assault on disease. Nurses are seen in the fantasy as depending entirely on the perception and orders of the physician," fact which is not true;
2) "Physician: the natural leader of the Health Team" described by the authors as the belief of the physicians that it is they who should be the team leader, despite the fact that they spend a very short amount of time with the patients in comparison with the ward nurses, and it is the physicians who should coordinate the healing process.

Regarding the second point, both the nurses and physicians have different views on what is important to the patient, and the nurses do not appreciate it when someone imposes something just on the status basis.

McKee (1970) also adds a different perspective by maintaining that, as the physician is not an actual employee of the hospital, the administrator is seen as interfering or restricting physicians' duties. It must be pointed out that it is the duty and responsibility of the administrator to provide the resources for the physician to accomplish his work, and the former must see the 'big picture' and provide the medical staff with what it requires. This also includes balancing unit/departmental access to resources, and not only accomplishing medical staff/personnel requirements.

However, Hewett et al. (2009, p. 1733) argue that clinical work encompasses negotiations between all the actors and "where the absence of explicit rules continual bargaining and negotiations characterize the organizational life of a hospital." This is so due to the nature of the service provided to its clients: the patients. Not one individual is able to answer all the needs of the client, requiring thus team-work. The negotiation can be extremely demanding, as a result of different power structure, power status, different goals, and others. Sometimes, the negotiations actually fail, to the detriment of the patient.

According to Chervenak and McCullough (2001), leadership needs to be based on values that provide appropriate direction for exercising influence and control in a constructive manner. Leaders need to be competent in the management of resources and employees. Since the managers have superior influence and authority to exercise power, they must exercise it through an ethical prism. The most basic parameter needs to be the right of the physician to exercise authority when it comes to protecting the interests of the patients. This aspect is mentioned and upheld by all the surgeons interviewed for this study. Engel (1969) believes that autonomy exists on an individual level as well as on the group level. Individual autonomy can be described as the individual's control over his work and activities on a professional level, entailing the right to deal with patients with freedom. On a group level, autonomy can be described as its role in influencing and controlling the activities of the entire profession. Yet, this autonomy also depends on the manner in which it is used. The concept of medical ethics requires the virtues of self-effacement, self-sacrifice, compassion and integrity. The physician can define and uphold professionalism in healthcare institutions by applying the aforementioned virtues. On the other

hand, there are also vices that can corrupt: unnecessary bias, self-interest, corruption, and callousness (Chervenak and McCullough, 2001).

Bates and White (1961) focus on how the ability to make decisions, exercise authority and control were subjective to each triad group, with each group trying to increase their power and control in the proceedings; this is viewed as an imposition by the other segments. However, most parties involved believe that the administration should have enough authority to make tough decisions, and doctors should have a say in the surgical procedures. The main problem is between the administration and physicians. Additionally, Bates and White (1961) also found in their study that there is no agreement regarding the financial management and operating schedules. The nurses and administrators have almost the same positive perceptions regarding other groups; yet, the physicians are thought of as selfish and opinionated, failing to follow orders, rejecting any kind of feedback from other parties. Building on the work of Bates and White (1961), McKee (1970) concludes that one of the major concerns in the healthcare system is the distinctive perceptions of the different segments involved. Physicians, nurses, and administration have all been known to view the control hierarchy in separate ways. This is confirmed latter by Bunderson et al. (2000) who explore the topology that provides a reference frame for comparison and analysis into differences in ideology that may exist across organizations and amongst individuals of different segments of the work force.

Mauksch (1973) is of the opinion that healthcare requires not only the individual's effort, but also a mandate that needs to be followed and implemented in order to have the best outcomes. He further states that the sub-entities involved in the healthcare system are equally important, as they have their respective functions, which need to be carried out, in terms of realizing the larger objective with this work. The different groups (surgeons and nurses) are crucial in understanding their respective interactions, the team-work required to take care of patients. Isolating these two parties will not provide a clear picture. If nurses are the focal point, it is complicated to comprehend the scope of their interaction with the physicians, which in itself is a separate segment. Similarly, paying attention to doctors alone will not provide sufficient insight into their dealings with the nurse-staff, and hence to actually develop a holistic framework of the involvement and functionality of sub-entities on their own, as well as a group, a cumulative focus needs to be made.

Coordination

As it was noticed that there are different hierarchies, and staff that is specialized in very specific mediums and components, the administration of the hospital must focus on one of the crucial aspects that keeps the hospital running efficiently: coordination of resources. The coordination effort falls under the auspices of the administrator, may he belong to a specific surgical unit, or part of the 'bigger picture', one unit that concentrates on the overall coordination between different units.

Obtaining economies of scale utilizing contingency theories and in the context of resource expenditure requires intricate working, and it is often complicated to ascertain. Since resources are procured for various sub-divisions within a company, duplication of effort is common. Moreover, sub-divisions and individuals are only aware of their own roles, seemingly unaware of the larger picture, possibly resulting in 'missed targets' at the organizational level. This is one of the reasons why the actual application of contingency theory in the real world is difficult. True and valid coordination of resources and information is hard to achieve, yet they are the main ingredients that can hold structures together.

Moch and Morse (1977) believe that organizations which are functionally differentiated call for greater integration and increased coordination among the different subunits and/or departments. Different units within an organization, although functionally independent, generally tend to compete for the same resource pool (Lawrence and Lorsch, 1967). The significance of optimal resource allocation becomes more complicated when the number of units competing for the same resources increases. Hence, optimum allocation and utilization of resources requires strict control and monitor protocols.

At the same time, Perrow (1961) is of the view that administrative dominance hinges on coordinating complicated procedures and complex tasks. This is the case because physicians are not always able to manage large number of supporting staff members involved in the process. Furthermore, Perrow (1961) suggests that administrators are in an excellent position to control and govern not only the personnel, but also the practices, freeing the physicians of the mundane tasks. Having this approach, the latter can utilize their time elsewhere. This was confirmed by most interviewed physicians of the present study. The high functionality often demanded by physicians can be mitigated to some extent, by providing support in times of conflict. Rico et al. (2008) focus on the dynamic adjustment which impacts on implicit coordination, similar to

Weick and Roberts (1993) who studied the effect of the collective mind, and Gersick and Hackman, (1990) who researched on habits and routines of the taskforce.

Rico's et al. (2008) work highlights the assistance to the theory of implicit coordination. They find that teams develop tendencies which become habit or routine (Gersick and Hackman, 1990), with work distributions and interrelation patterns amongst the different members of the team (Gersick, 1988; Weick and Roberts, 1993), and irregular and less frequent group discussions about strategies necessary to determine a joint task (Hackman and Morris, 1975). Team coordination can only be completely comprehended once cognitive structures and processes employed by the team members are carefully evaluated in greater detail, (Fiore and Salas, 2004; Gibson, 2001; Marks at al., 2000; Marks et al., 2002; Mathieu et al., 2000).

The overall model of the research conducted by Rico et al. (2008) is based upon the increase in understanding of the team members coordinated functions, eventually leading to enhanced team work and improved coordination amongst the taskforce. Implicit coordination involves some of the most dynamic aspects of team work, as well as taking into account the behaviors of the task force, and how they adjust as a collective entity. This is an important factor that surgeons mentioned when interviewed: the surgeons prefer to perform a surgery with the best team available. There are situations when a surgery is postponed because a surgeon does not have a 'perfect team' (from his perspective) in the OR.

According to Rico et al. (2008), the two most significant elements that contribute towards implicit coordination are dynamic adjustment and anticipation, which are derived from team structure and team members' knowledge. To be able to model implicit team work, the role of the team members and the nature of their knowledge need to be fully appreciated (Cannon-Bowers et al., 1993; Klimoski and Mohammed, 1994; Kraiger and Wenzel, 1997). Furthermore, Rico et al. (2008) state that in fully functional and optimally performing teams, each individual member is aware of the overlapping or shared efforts, and have a greater understanding of their own responsibilities.

Rico et al. (2008) believe that the content of the information and knowledge depends on the team's roles and functions; yet, in order for the team members to develop implicit coordination, the content that *becomes* pertinent is the environment in which the team members are participating, their specific roles and finally, each individual's ability. In a medical care facility, physicians, nurses, support staff, etc., have their own specific duties that they need to

perform. In this particular setting, whilst the physicians are aware of the medical procedures that are required, the technicians' are the experts at operating the electro-medical equipment (for example), anesthetists to perform the anesthesia before operating procedures. For such an occasion, team situation models would allow the team members to be able to develop implicit coordination, benefiting to the health services provided. This was confirmed by different interviewees who stated that in the OR the team is cohesive, everyone knows what their role is, and the main focus is on the welfare of the patient.

As mentioned before, there are different types of organizations, of which the 'hospital' is a special case. Due to the different characteristics of the hospital's operations, including the segregation of different skills, professions, and specialties, different types of management techniques are required. Thus, the administration of a hospital is a very complex task where the coordination effort between all hospital's stakeholders plays a key role. Yet, the manner in which different actors interact is also decided and defined by the way decisions are made/taken in the hospital. The two major segregation between decision making configurations that an institution can be organized are the centralization or decentralization of decision making. Each one of these distinct decision making rationalities has specific benefits, but also deficiencies.

DECENTRALIZATION AND CENTRALIZATION

One of the major structural differences between organizations is the centralization and/or decentralization of their decision making and allocation of resources that result in distinct types of interactions between the stakeholders of the institution.

There are different manners in which an organizational structure can be designed. Decentralization should be the chosen structure when fast responses are needed regarding new technological advances or environmental demands. In these cases, the information conduit is from lower to higher hierarchies, argues Aoki (1986). At the same time, centralization has its own benefits as it helps the coordination between different actors.

Decentralization

In the hospital under study, the ES scheduling planning is decentralized. The following is a description of the process: a patient comes for a consultation, and after the required medical examinations are done, the surgeon proposes surgery to the patient. For simplicity sake, it is assumed that the patient wants and accepts the surgery. A future date is proposed for the surgery, and the surgery is 'booked'; the unit secretary or unit administrator is responsible for contacting the patient before he is admitted to the hospital for the surgery. The nurses are responsible for preparing the patient for his surgery, taking into consideration the recommendations of the surgeon; these recommendations are available for review in the patient's file. The patient is admitted to the hospital, most of the time, the same day that the surgery takes place. And, the patient undergoes surgery.

Some of the elements that complicate the situation include:

1. The proposal for surgery by the surgeon can also happen when the patient is admitted and present in the hospital; yet, the surgery is still elective, i.e. it will take place at a future date. In this case, the patient will go home (if he is able to), and he will be re-admitted to the hospital before the surgery.

2. The booking of the surgery for a specific unit needs to be approved by the Chief of the unit, which is requesting specific OR times for his unit. The time allocated to each specific unit is provided by the Chief of Surgery, the one responsible for all the surgeries and surgical units in the entire hospital. One can easily assume that all Chiefs would like to secure as much OR time as possible for their own units. Moreover, each surgeon would like to have as many surgeries as possible, as he is remunerated by how many surgeries he performs.

3. The surgical administrator of a specific unit is responsible for managing the specific unit's surgical schedule, making sure that all surgeons have, in certain cases, proportional OR time. However, the proportional OR time rule for surgeons is not applied in all the units as there are other methods to allocate OR time (seniority, longer waiting list, etc.).

4. In most cases, the Chief of the unit, which is the administrator is a surgeon. Therefore, he has two hats to wear: surgeon and administrator.

5. The master schedule of surgeries is provided by the administrator at the Chief of Surgery level. In certain cases and situations, any interference with the proposed elective master schedule at a later date after it is accepted, needs to be approved by the Chief of Surgery. The

administrator of the master schedule of surgeries is considered to be central as he needs to ensure that the interaction between different units and different surgeons must come together in the Master Schedule.

The reason why this system is considered decentralized is that decisions are taken at the surgeons' level, and it is the surgeons who decide when patients should have their surgeries. This is originally done as a time-frame is needed when the surgery is required. It must be noted that some patients who arrive at a later date may receive their surgeries before other patients who are already on the waiting list and have already waited. All this does not diminish the surgeons' authority as they are the experts in their profession and they can take decisions disregarding other surgeons and other units; hence, having a decentralized decision approach.

Burton and Obel (1998), considering contingency theory, are of the view that interdependence between groups should be minimized, in order to provide autonomy to the respective departments and sub-divisions. Doing so enables the company to break-down tasks and issues into smaller problems, making it easier to deal with. The same approach is utilized today in project management projects. This methodology ensures that less information is required to solve a problem (Galbraith, 1973). Furthermore, Burton and Obel (1998) state that top management is rarely involved in the day-to-day operational problems of the organization. This is a consequence of a decentralization strategy (Duncan, 1979). In particular, a divisional layout improves response-rates and flexibility within a company, and allows for organizations to specifically target consumer/customer requirements. However, such a divisional structure demands high level of coordination between the sub-sections, and also a method to control individuals in order for them to perform appropriately.

Furthermore, one aspect that does not help the current situation and increases decentralization is the fact that the hospital is a *federal system* where the units form the federation and they have autonomy and discretion regarding the operations within their own units. It is the patient who is the force behind the coordination. Rational bureaucracy brings some formalization and standardization, yet these are only mechanisms of medical coordination.

Due to the actual decentralization processes and principles of the hospital, the work is performed in silos. This means that units do not actually interact with each other, and surgeons within the same unit have the same approach. The 'coming together' is done by the administrator when he combines the actual schedule, either for the unit or for the hospital. It is the Master

Surgery Schedule that combines all surgery units and all surgeons; this is performed at the hospital level.

Centralization

Blau and Schoenherr (1971), Child (1973) and Pugh et al. (1969a) showed that there is a negative relationship between an organization's size and scope and the centralization of decision making. Hospitals today have a decentralized structure, and decisions are taken at the unit level. This is to be expected as there is a high degree of specialization. However, decentralization can lead to inefficiencies. The debate between centralization and decentralization is long standing. One argument is that centralization helps to manage high volumes of work and contributes to improved results, while, as McKee and Healy (2000, p. 805) put it, allowing the hospital to "achieve economies of scale". This is well researched by Aletras et al. (1997) that suggest the optimal size of beds in a hospital is to be between 200 and 400. However, McKee and Healy (2000, p. 805) make the counter argument that decentralization "improves population access and reduces inequalities". Zabojnik (2002, p. 2) summarizes the trade-off between the two management philosophies as follows: "on the one hand, delegation leads to a better utilization of information scattered throughout the lower levels of the firm's hierarchy; on the other hand, it entails a loss of control for the upper-level managers." Quite interestingly, it has been shown that "task predictability has a positive effect on centralization of policy decision but a negative effect of the centralization of routine decisions" (Comstock and Scott 1977, p. 198). These findings support those of Reeves and Woodward's (1970) by suggesting that if a task is more predictable and repeated, the higher the chance to separate policy making and decisions/execution.

At the highest level within the hospital, resources are in fact centralized. However, once they are distributed to the individual units, representing the decentralization of resources, the units do not need to have a high degree of interaction between them.

Another potential response to these situations, conflicts and tensions might be to centralize the information system. This would mean the centralization of some part of the information regarding the elective surgeries, more specifically, the centralization of the planning of surgeries at the unit level and at the hospital level. This solution ensures that some of the difficulties with the decentralized planning are overcome.

For example, the interaction between staff of different units would be reduced. All the surgeons, depending on the rules built in this subjective system, could have a fair allocation of OR time. The unit which would have the most surgeries would be allocated more OR time. This system and the manner in which it would allocate surgeries could be built-in, depending on the policies that the units and hospital deem necessary and appropriate. Building on the example of the allocation of OR time, colon cancer surgeries must be performed in less than 28 days (requirement imposed by the provincial government). The system could make the necessary calculations and adjustments required to ensure that all these surgeries are performed in the time allocated. The centralized system could be able to adjust the patients' needs, if the patients' surgery is becoming more urgent.

In the current decentralized system, there are problems where actors interact and are forced to apply different power strategies in order to secure resources for their own unit or for themselves. Therefore, a new system is proposed: centralization of decision regarding the scheduling planning of elective surgeries. The proposed computer schedule and model is an impersonal system where no one individual makes any scheduling allocation decision, and where surgeons only place the patients' *characteristics* in the system; these may include criticality, urgency and maximum possible waiting time, among others. Some interviewees do find this approach helpful, yet there is no consensus with the surgeons regarding this aspect.

Centralization provides different responsibilities including assessing rewards, budgeting, forecasting, and decision making. The capacity to process information is strongly linked with centralization/decentralization: the larger the information amount, the larger the decision-making mechanism, and the greater the decentralization in most organizations (Burton and Obel, 1998). Centralizing the information, and in certain cases, centralizing decisions and procedures would be an appropriate means to overcome, or at least to avoid, some of the pitfalls of decentralization.

For Kingston (1983, p. 1162), "organizational structure depends on clearly defined boundaries, that is to say, assumptions about the meaning of key concepts, the proper division of work and the legitimate exercise of power." Key notions of rank and proper division of work are present for medical purposes. There are directly and specifically clearly defined boundaries (the doctor is supposed to do X, the nurse is supposed to do Y). The higher administration provides specific guidelines to the units, and the information is dispersed from top to bottom. Yet, there

are side interactions between units, surgeons and administrators that offer a balancing mechanism when disparities arise. The side-transfers have an important role in ensuring the maximal use of resources.

Even though structure is important in the overall institutional layout, and the management and coordination efforts are made to ensure that all the stakeholders are on the same page, resources is one of the key driving forces that underline the basic reasons for the specific type of allocation: decentralized or centralized. Without the proper resources, a hospital cannot function. Furthermore, the available resources must respond exactly to what is required by the stakeholders. Organizations cannot survive if they do not respond directly to what is asked from them. This idea brings into context contingency theory which stipulates that an organization must respond to the demands of the environment, and ensuring that the resources available are properly managed in such a way that the outputs of the hospital do respond to the demands of the environment. The situation and analysis of the hospital become even more intricate what the latter is considered an open-system that is able (and must) adapt to what is asked from it.

Contingency theory

Bourgeois (1984, p. 590) maintains that contingency models provide a simple theoretical solution that is supported by data because the former were developed on structure/structural correlational analysis. The pioneers of contingency theory were Bruns and Stalker (1961), Lawrence and Lorsh (1973), and Woodward (1965). Even today, the works of Galbraith (1973) and Mintzberg (1982) are still extremely relevant to this conceptual framework. Furthermore, the research proposed by Daft (1991), Duncan (1979), Nadler and Tushman (1988) and Nadler et al. (1979) also significantly contributed to enhancing the understanding of this particular field. The research carried out by Burton and Obel (1998) and Burton et al. (2000) helps to expand upon the original concepts by providing a larger model that incorporates previous authors' work.

Due to the development of organizations and a very intricate environment, open-systems perspectives were taken in consideration. Kast and Rosenzweig (1974) believe that contingency theorists do have a "one best way" of the organizational structure setup that has the 'best fit' (Aldrich, 1975); yet, these are dependent on the different circumstances imposed by the environment. The 'fit' is defined by Donaldson (2001, p. 7) as a match "between the organization structure and contingency factors that has a positive effect on performance." As

Luthans and Stewart (1977, p. 183) put it, “the contingency approach is defined as identifying and developing functional relationships between environmental, management and performance variables.”

Contingency theory, as well as agency theory, refers to different methods of information administration (Chandler, 1962; Galbraith, 1973; Lawrence and Lorsch, 1967): the information is asymmetrically dispersed throughout the organization (Eisenhardt, 1989). At the same time, the information enables potential efficiencies and specific organizational forms are chosen over others (Galbraith, 1973). However, there are certain differences between the two theories. For contingency theorists, the main focus is with the “optimal structure of reporting relationships and decision making responsibilities” (Eisenhardt 1989, p. 63). Agency theory is concerned with the outcome of the reporting and decision making. For the current research, contingency theory provides the best coordination mechanism.

Luthans and Stewart (1977) divide the different variables in two great categories: primary system variables (environmental-suprasystem, resource-subsystem, management-subsystem) and secondary variables (situation, organization, performance criteria). The system performance is the aggregated component that measures the fitness of the system. The authors provide a clear description of the interactions between all the variables, replicated in Figure 2.

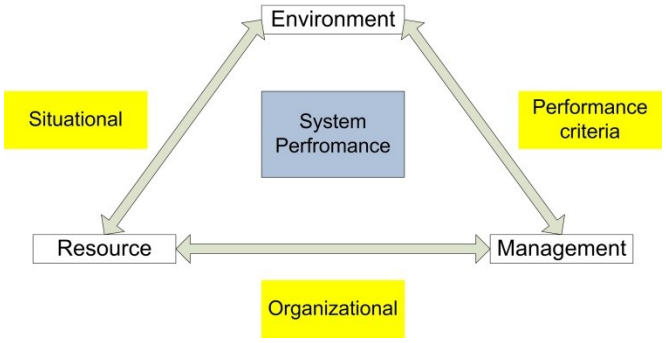


Figure 2: A summary of the variables and relationships in a contingency model*
*Luthans and Stewart (1977, p. 187).

In the context of contingency theory, the goals of the organization are set by the different stakeholders taking in consideration both the internal and external environment of the organization as well as the resource constraints (Luthans and Stewart, 1977). The environment in which an organization operates is extremely important as it determines its structural setup described by Lawrence and Lorsch (1967). The context in this view considers the organizational structure or the organization, including it hierarchy, internal and external rules and regulations. Thus, contingency theory “regards the design of an effective organization as necessarily having

to be adapted to cope with the 'contingencies' which derive from the circumstances of environment, technology, scale, resources and other factors" (Child 1973a, p. 237). Once again, the constraints imposed by the circumstances of an organization refer and reflect the variability, validity and value of any organizational outcome. These aspects are the ones that demand a reaction from the institution in order to adapt and provide the 'best fit' response that would ensure a more efficient outcome. In order to differentiate between the constraints, Ranson et al. (1980) distinguish between the organizational characteristics and the environmental ones. One important element that links the latter is the resources utilized. On one hand, they are provided by the external environment, yet they are utilized by rules and guidelines internal to the organization.

The structure of an institution needs to be modeled according to the particular set of requirements, either internal or external. Organizational structure needs to be adopted first, and then fine-tuned to serve the purpose most suited to its environment (Amblard et al., 1996). Companies need to constantly evolve and adjust according to the changes in the business environment; otherwise, they cannot survive in the long run. Although the structure of any organization is dependent upon the environment, it is important to note that the dependence is not just machine-like and deterministic in nature. The idea that a business is a closed system, and that organizational performance is only concerned with work procedures is out-dated in today's interdependent economical building blocks. The structure of a 'good' organization not only depends upon the environment, but also on the goals that the organization desires to accomplish. According to Burton and Obel (1998), some structural parameters become increasingly significant, depending on the contingent features encountered by the organization and internal stability within a business corporation.

Galbraith (1973) believes that there is no perfect structure, rather a structure that is better suited to the particular needs and requirements of an organization. Processing information is one of the most critical aspects of successful business operations (Galbraith, 1973). Nadler and Tushman (1988) also proposed a three-phase design to manage information within a company: 1. grouping individuals into different sections, or sub-units; 2. the coordination of the sub-units in order to achieve optimal performance; 3. managerial mechanisms that provide the rules and regulations of the operation itself, thus controlling the information flow and processing.

Tangentially, Nadler and Tushman (1988) also incorporate in their design one of the most important aspects of coordination, besides Galbraith's (1973) ability to share and process information: resources. As mentioned previously, resources are one of the driving mechanisms of the hospital. Without access to the proper resources, surgeries do not get scheduled, and worse, they get canceled because of lack in a timely manner to the resources needed. Furthermore, the manner in which resources are distributed could be through a centralized or decentralized decision, aspect previously argued.

Resources that are present and available to the staff are also important, and they may not be only physical in nature, but also non-physical, such as alliances, unions, relationships. Resource dependency theory can provide some of the frameworks employed in hospitals and can answer some of the reasons why certain allegiances between units at the medical staff level are formed. Yet, from a bird's-eye-view, the core values of dependency theory are not applicable within the context of a hospital, i.e. the interaction between the different units or individuals. The reason is that the hospital must ensure its legitimacy to its internal and external constituents; therefore, it cannot undermine one department to the benefit of another. All departments have the same hospital goals and provide the same hospital services: medical care to patients.

Bamford and Griffin (2008, p. 215) conducted a study on eight operational teams in a UK National Health Service hospital by a combination of survey and group discussions. In conducting their research on human resource management within the operational team-work of healthcare workers, they found that the composition of a team had little operational description. In other words, what really led to effective team-work was not an organizational support for team-working or the establishment of multi-disciplinary teams, but rather other factors, such as: leadership skills, frequent team meetings, and a climate of trust and openness. It is argued that these are part of the non-physical resources needed.

Bamford and Griffin (2008) further emphasize that what they have learned from the research is a result of specific circumstances in one UK NHS Trust, and these are relevant for the operational management of healthcare teams in the UK Public Sector. They have found six crucial messages, provided in Appendix A. In the same Appendix A, a figure shows the operational team-work inputs, processes and outputs that deliver team effectiveness. Some can be characterized as physical resources and others as non-physical ones.

Lega and DePietro (2005, p. 268-269) examine how resource integration is accomplished through resource pooling. Beds, operating rooms, equipment, nursing staff are allocated to a unit and then are shared between all functional specialties. For example, if beds and ORs are scheduled for a single specialty and specialists, but are under-utilized, the Chief of the unit can reassign them to other specialties that have a waiting list. Another point is that utilization caused by unplanned events such as emergencies due to aggravation of the patient can be decided by the head nurse of that unit. This also suggests that the nursing profession might have a decisive role in carrying responsibility for the patient`s medical needs, and ensuring that they are met (Mechanic and Aiken, 1982). Despite this aspect, the nurses' recognition occurred only recently. The doctor can assess, on a clinical perspective, if there is a need to admit a patient in a specific ward, but he lacks the assessment if that ward will provide enough care to the patient, because of its staffing level, ward maintenance problems and others (Campbell, 1980). From a managerial point of view, it is clear that admitting someone is a task for the wards nursing manager. This is especially true if the ward consists of more than one specialty. The wards with shared ORs and equipment should try to maximize coordination of the allocation of fixed or "leading" resources (Vissers, 1998), which would result in an increase of their flexibility, having a lean pull-system. The author differentiates "leading" resources, such as OR capacity, from the "following" resources, such as beds and nursing staff. These are examples where an administration decision is 'readjusted' in the front lines.

Lega and DePietro (2005) notice how the allocation and management of these resources are performed through an interdependent process. This is done by the unit administrator, who is appointed by the hospitals top management, with the consensus of the unit chair and/or by the head nurse. Units generally have at their discretion how to proceed, as long as they are profitable/efficient; it is for this reason that the authors claim that clinical governance is still in its "embryonic stage". Giving an example of Mount Sinai Hospital in New York, the researchers argue that hospitals should evolve toward a more care-focused approach, by reorganizing departments, based on patient grouping and multidisciplinary teams. Lega and DePietro (2005, p. 273) also advocate "engagement of professionals through reinforcement of organizational mechanisms, with the aim of a better alignment of their interests with organizational goals" as another important objective.

The bureaucratic realm cannot be avoided in any institution. For any hospital in Canada, having a bureaucratic rational as the cement between the different units and actors is the cornerstone of this specific organization. This cement would be the glue that keeps everything in place and that links all the aspects, actors, and interactions found in a hospital. Decisions can be made in a centralized or decentralized manner, resources allocated through any method, administration can coordinate under any auspices; yet, all has to go through a/the bureaucratic process. Bureaucracy was, is and will be ever present in the hospital setting.

BUREAUCRACY

Reay and Hinings (2005) have the same direction as Martin (1980, p. 68) that provides certain potential dangers due to the characteristics of the hospital environment because there is "a struggle between opposing forces" and specific strategies and tactics need to be employed. One is required to understand how a hospital works, the strategic and tactical politics that are present in it, and how these politics apply to and for the administrative and medical levels of the hierarchy. This idea was present in all of the interviews performed with the surgeons, as all of them would want more OR time. The hospital is a hierarchical organization. Martin (1980) explains very well the dual authority/authoritarian system present in any hospital: the clinical hierarchy formed by the medical staff, and the administration hierarchy, which most of the time is not composed by medical staff. The previously mentioned struggle is between these systems, hierarchies, and members. Moreover, the medical staff sees the administrative staff as intruders, and tension is created between the two parties. Building on Martin (1980) opposing factors and struggles, Young and Saltman (1985) have the exact same perspective on the matter, and this is why centralization (the removal of power in certain instances) is recommended.

The present research does not challenge bureaucracy; the former is just an extension of the latter, in a very specific context, having the same rational as Friedson (1978, p. 982) who states that "the issue of interest, however, is not bureaucratization in and of itself as an ideal model, but rather the particular qualities it will assume in reality." The main idea of bureaucracy, succinctly put, is to have human and non-human resources, thus creating a social context, and a management method that ensures the best utilization level for the resources. This may not be the case as social actors may utilize the resources in an inefficient manner. The last point aims at

having trained personnel to use the resources, and the 'consumption' of the resources is done in an effective and efficient manner. Furthermore, many bureaucracies do not take in consideration this aspect, meaning that they are not fully opened to different viewpoints, trying to adapt to the environment, and implement new methods of doing business.

The system does work to a certain degree, and "organizations do some of the basic things they do because they must – or else!" (Thompsons 1967, p. 1). However, there might be better ways to undertake activities in the hospital; it is this 'if it works, do not meddle with it' mentality that is challenged in the current research.

Lega and DePietro (2005, p. 263) provide some "needs [that] reinforced the adoption of a functional specialties based design":

- there exists the need to separate the areas governed by different physicians in the same hospital or across different hospitals;
- distribution of medical work and the ways doctors are organized is based on individuals professional interests, finances, rivalries and career opportunities, rather than by analyzing the needs of the patients;
- requirement of maintaining viable control, because managing and supervising is a challenge.

Bucher and Stelling (1969, p. 13) clarify the core nature of a bureaucracy that is typically understood as "characterized by a hierarchical chain of command, clearly defined duties and obligations associated with each office, with goals and procedures determined at the top and conveyed down the chain of command-a type of system which would discourage autonomy and innovation among the ranks."

For the purposes of this analysis, there are two types of bureaucracies: general – considering the forefather of bureaucracy, Weber and his contributions to this important topic; the professional bureaucracy, which cannot directly be qualified using Weber's bureaucratic specifications. The professional bureaucracy is important as in the hospital, there are different professions that perform very specialized tasks, and the members of these groups can have a lot of influence on the system in general.

For these reasons, after describing Weber and the Weberian bureaucracy, including aspects of the different types of conflicts and power statuses, the professional bureaucracy is

introduced with its own take on the hospital's interactions and the role of the administrator is such a system.

Weber and bureaucracy

Weber's bureaucracy can be described and defined by the following elements (Blau and Scott, 1962; Engel, 1969; Litwak, 1961): impersonal social relations, employment (and advancement) based on merit and competition, obligations imbedded in the position (not in the individual), a hierarchical structure of authority (rooted in the positions) where power is centralized at the top, dichotomy of administrative and policy positions, rules and regulation of behavior and official action, and, most importantly, division of labor, i.e. specialization.

However, there are certain elements of Weber's classification of bureaucracy that cannot be applied to the healthcare. McKee (1970, p. 25) describes the bureaucratic environment of the hospital and adds an interesting note: "The modem hospital is a highly stratified and complex organization. It has become an extremely bureaucratized establishment with a multitudinous division of labor, formal channels of communication, exacting regulations, and yet, for a bureaucracy, a somewhat confused hierarchy of authority." The confusion of authority is only partially to blame. The interactions and social strata have also their influence to the complications.

Table 3 is adjusted from Weinman et al. (1979, p. 32), building on previous research by Pugh et al. (1968, 1969a, 1969b) and Pugh and Pheysey (1968), and provides six hypothetical dimensions of structure which are present in any organization, to different degrees. The distinction between bureaucratic centralization and the proposed centralization of

Dimension	Understanding
Specialization	division of labor within the organization and involving two aspects: the number of specialists, and the degree of role specialization
Standardization	number of types of procedures and the rules and policies developed to guide the activities of the organization
Formalization	extent to which procedures (and communication) in an organization are performed (written)
Centralization	locus of authority to make decisions affecting the organization
Configuration	system of relationships determined by the top-down/bottom-up authority, and their respective responsibility
Traditionalism	degree to which the organization is guided by customs rather than formal rules and written procedures

Table 3: Six hypothetical dimensions of structure*
*Adjusted from Weinman et al. (1979, p. 32)

this research needs to be made: the latter only concerns a very specific aspect of the organization --- the planning (scheduling) of elective surgeries.

Contingency theory can explain partly why and how individuals and/or groups fall to different degrees into these dimensions. It is also through the lens of the same theory that uniform and non-uniform events can be rationalized to coexist in a healthcare institution.

For Weber, society and organizations are segregated into value-spheres that are competing; each sphere has its own obligations, norms and values (Townley 2002, p. 164). Weber's *impersonal* bureaucracy sustains, and it is very well adapted to, a high level of uniform events. Litwak (1961, p. 179) believes that individuals are "faced with non-uniform events which are not clearly covered by rules are insecure." Once again, due to lack of security, status and position, tensions between actors arise. Even if it is implicitly, Weber maintains that the traditional areas of knowledge have a stronger presence in the organizations contrasted with social skills. It is this social skill boundary that requires some of the borders to be addressed and rearranged in order to reduce the stress.

It is easy to see that tensions and conflicts might arise as a result of interactions between different stakeholders that maintain different structural dimensions. Bucher and Stelling's (1969) chain of command also can contribute to a tense atmosphere in the organization. Therefore, a proper understanding of struggles that different stakeholders have, taking in consideration the concept of power and its influence on the coordination aspects of the hospital are necessary to be understood.

Conflict

Reay and Hinings' (2005) observations are similar with those found by DiMaggio and Powell (1983) that organizations are a battlefield where skirmish battles and clashes take place and where different sources of power are used via different tactics. Each actor has their own power sources, and thus, their own tactics. Hewett et al. (2009, p. 1733), building on previous research, state that "team conflict is often attributed to socio-cultural factors, status and power structures, rigid professional boundaries, differing views on collaboration, desire for professional autonomy, the complex and pressing nature of work, and desire to avoid or suppress conflict." Therefore, there are specific reasons why such conflicts exist. For someone who does not know how the general hospital works from an administrative/interaction point of view, the authors'

statement may be contradictory to the common belief that the hospital is a 'well-oiled machine' where the entire system is there for the betterment of the patient.

According to Wilson (1963), relationships amongst staff and workers are defined by unclear authority patterns, competition, competence and prestige. The physician is thought of as the individual least affected by hierarchical control, due to enhanced skill, talent and status. However, Eakin (1984) highlights a key element in regards to managing the staff, after conducting interviews with the administrative personnel of healthcare institutions. According to the administrators, the problem in dealing with physicians arises from the doctors' financial independence, difference in status between administrator and physician, and their claims for complete autonomy over their work. For the administrators, interacting with physicians is one of most complicated aspect of their job.

McKee (1970) believes that two separate authoritative entities exist within the system. From the operational side, the administrative staff goals are to 'maintain' the plant, financial affairs and non-medical needs of the patients. On the other hand, the physicians are tasked with providing the medical care services. According to Scott and Volkart (1966, Part 3), the distinction amongst the specific functions of the two parties is hazy in some places, which often results in strained relations. Administration laments the physicians' interference in the administrative work, and the clinicians take offense by the administration's interference in medical procedures. The most common area of conflict arises from the differences in opinion of the physician's definition of an emergency case, in comparison to keeping to a time table set-forth by the management.

Furthermore, McKee (1988) collected data on the relationship between managers and doctors in a psychiatric hospital, revealing that the conflict between consultant psychiatrists and general managers is particularly acute and decision making becomes additionally politicized. The backdrop of the severe conflict is due to the difference in opinion in terms of the seriousness of the illness, methodology of treating the patient, objectives, controlling the outcomes and motives of each segment. This conflict is even more enhanced due to the advent of cost-effective business practices. To add, McKee (1988, p. 312) points out that in this case, "the managers were more influenced by their day to day experience of the clinicians which were described as less than innovative or supportive of change."

Clinicians are often accused by the administrators to hide behind autonomy and clinical freedom, when times call to make unpalatable decisions, concerning patient's medical care. Their continued efforts to rebel and refusal to adopt the policy of the managers are considered to be a hindrance in hospital administration, eventually effecting the manager's success in running and organizing the healthcare institution (McKee, 1988).

It is not surprising that the physicians and administrators are often skeptical, with both parties keeping negative perceptions of each other (McKee, 1988). On one hand, physicians view the managers as careerist, individualistic in nature, looking only to optimize profits and bonuses; the managers think of doctors as selfish, greedy and too one-dimensional. Yet, McKee (1988) also believes that it is the administrator's job to bridge the communication gaps with the physicians in order to reduce the impact of the political environment.

Most of the time, managers are focused on achieving short term objectives, as well as catering for the day-to-day tasks, and so the attention towards the diplomatic aspects of the job are often overlooked. Hence, administrators' success is strongly linked to cultivating positive interactions with the physicians, as they are the ones who have the ability, vision and expertise to claim a majority stake in the state of affairs of the healthcare system. Proactive management of the aforementioned processes needs to be evaluated, in order to implement a policy change and have proper working relations (McKee, 1988).

According to Ranson et al. (1980), individuals and groups of an organization have power because they have command over resources. Allocation of these resources gives them power to define outcomes and to "recreate rules, positions and budgetary allocations which ensure the reproduction of those bases" (Greenwood et al., 1977; Ranson et al. 1980, p. 8). Structural framework is a key tool which groups use to preserve and sustain their power in organizations, and groups work hard to create structures that would become institutionalized. Ranson et al. (1980, p. 8) realize that "the operation of the power system" is connected with the "strategic decision making" (Child, 1972.), and by that, to the conflicts of interests and principles that are underlying a specific activity. In this case, power is understood processually: issues occur, information is submitted, and "decision are made about roles, rules and authority relations" (Ranson et al.1980, p. 8).

DiTomaso et al. (2007, p. 475), similar to Sachdev and Bourhis (1991), define power as "access to and control over" resources that are limited. Even though the authors' focus is solely

on the personnel, the people who actually do the work, they do incorporate the idea of class and control of certain classes over others. Young and Saltman (1985, p. 24) apply this definition in the context of a health center and provide the presupposed gaps in the 'standard' power infrastructure; they look at "power as a determinant of organizational decisions [that] exists on three different but highly interrelated levels: 1. within a given medical specialty; 2. between various medical specialties; 3. among different occupational groups within the hospital." This description mimics the current power struggles and tensions between the various *factions* in the Montreal region hospitals. The scuffle between levels is also very well described by Wilson (1963, p. 72): "these are, first, the diffusion of authority, and, second, the excruciating struggle for occupational prestige." Due to the differences in prestige and authority, tensions are developed. These tensions are also nourished by the fact that members of the different groups want to accomplish either goals for personal benefit or goals that support the group to which they belong.

The professional bureaucracy

The standard bureaucratic structure consists of formalization, decentralization, vertical span and specialization. Bureaucracies can be organized according to several different structural models. Each structure experiences different pressures and each structure has particular contexts to which it is best suited. In the hospital setting, professional bureaucracies often proliferate. Medical professional bureaucracies present a unique set of complexities to the efficient functioning of the bureaucracies because of the exigent nature of the medical profession. Most of the time there are difficulties in the application of bureaucratic theory to the medical professional content. If, as Light and Levine (1988, p. 12) suggest, professionals are largely defined by their autonomy, and "bureaucracies have a way of generating their own sources of power through regulations and hierarchy", how is that conflict resolved?

Weber (1968) also portrays very important elements of the professionalism order (Carr-Saunders and Wilson, 1933; Scull, 1979), by stating that "guilds are a form of closed order which pursues quality, prestige, and profit to the mutual benefit of its members" (Light and Levine 1988, p. 21). It is through this perspective that physicians started to unite into a professional order.

Bucher and Stelling (1969, p. 3) argue that there are limits to applying bureaucratic theory to the analysis of professional organizations because "professionals create their own distinctive social organization within a larger organization", and politics, negotiations and alliances characterize these organizations. The authors also stipulate that tensions could arise between the different professionals and administrative rationales in any organization. In addition, the professional's relationship to authority as formative of self-definition represents a complication in the chain of command that is typically existent within a well-functioning bureaucracy. Professionals, as Bunderson et al. (2000, p. 386-387) define them are "groups of individuals who are trained to perform a specific type of work whose identity is at least partly drawn from that work and who share norms and values which apply to but extend beyond work-related matters" (Brown and Duguid, 1991; Trice, 1993). Bucher and Stelling (1969, p. 13) provide a more detailed description of the professional as "a person who derives his aims and methods from a professional body, works independently, and who commands the privilege to autonomously determine what should be done and how it should be done." In the context of these individuals, where communities are formed by a professional and technical workforce (Van Maanen and Barley, 1984), whose social groups, values and identities grow at least to some extent out of work, and whose work has been treasured by the definition of medical professionalization, decisions that should be made with administrative rational (Van Maanen and Barley, 1984) are influenced by professional thinking. Furthermore, Heydebrand (1973) maintains that professional organizations "tend to predominate under complex task structures".

Freidson and Rhea (1963, p. 119) argued that the professionals' autonomy within an organization is contrary to Weber's rational-legal bureaucratic model. Satow (1975) also believes that the professionals will follow, hold and defend the guild norms (rules) when (and if) these are divergent with the administrative rules. In the same train of thought, Bucher and Stelling (1969) also do not consider that the Weberian bureaucracy matches the organization desired by the professional cohorts. In their study, they realized that a 'new' organization is required, one that combines the guild mentality with bureaucracy, more precisely, the type of organization that results from the interaction of bureaucracy and professional mentality. In the context of a hospital, professionals often have to take on administrative tasks that are part and parcel of an efficiently operating organization. The autonomy of the professional can come into conflict with administrative tasks that require administrative, rather than professional thinking.

As organizations and their structures are not similar and 'one-size fits all' approach is erroneous, the application of bureaucratic elements must take in consideration the nature of the organization, the environment and the members of that organization. Therefore, there needs to be a strict distinction between the professional and administrative groups as each one of them has different goals and objectives. Furthermore, the interactions within and between these groups are very different, resulting in conflicts.

An important issue in the professional literature is the impact that bureaucracy has on the professionals. However, the latter also affect and influence different strata of bureaucracies. Therefore, causality is in question: professionals affect bureaucracy or vice-versa? To this, Engel (1969, p. 30) adds that the administration sectors restrict professionals activities and causes the latter to be dependent on the organization: "his [the professional] association with a bureaucratic organization could therefore prevent the professional from fulfilling a fundamental requisite of professional behavior – serving the best interests of his clients."

By contrast, unlike physicians whereby the locus of power is in constant flux, Comstock and Scott (1977, p. 199) observe that nurses, do not behave "as autonomous professionals demanding the privilege of exercising individual discretion, as physicians are likely to do (Freidson, 1970)"; they work within the hospital's administrative structures "in a heteronomous professional arrangement" (Comstock and Scott 1977, p. 199) as they lack a 'power-base' similar to physicians (Etzioni, 1969; Hall, 1968; Scott, 1965). The authors discovered, contrary to their belief, that head nurses increased standardization and centralization of decision making. In contrast to physicians, nurses' power is based "on organizational position" rather than on "individual expertise". Comstock and Scott (1977, p. 199) realize that the nurses use bureaucratic controls and constrains to govern "the behavior of subordinate workers" (Heydebrand, 1973). As head nurses are the ones responsible for wards from all aspects – supervision, coordination and control of nurses and orderlies – they centralized the decision making and enforce strict procedures that govern the activity of the wards. Nurses delegate, but this does not mean that they are deferring their expertise. However, transferring authority, i.e. delegating, is sometimes a root of negotiations and conflicts. Mauksch (1973, p. 825) argues that the title of the task's performer invokes certain assumptions for responsibility of the task's results. Professionals are not to be confused with professional tasks. He points out that the "the professionally performed task does not preclude delegated activity", and as such, the successful carrying out of the task

itself, whose goal is "the reduction of the client's assessed problems," should supersede the assumption of its success because it is performed by a titled professional (Mauksch 1973, p. 825-826).

Nonetheless, the importance of *title* is difficult to challenge. Light and Levine (1988) point out that the most influential source of professional power comes from a widespread cultural predilection to hold medical professionals in high esteem. Although culture provides the "most fundamental source of professional power", argued also by Barzun (1978), the shifting nature of culture and the finicky nature of trends, make the cultural source of power less easily identified or quantified (Light and Levine 1988, p. 12). This 'supreme' authority of physicians is replicated through the culture of medicine, class hierarchy, and institutions (Navarro 1976, 1986; Waitzkin 1983). Physicians are deeply invested in this title carrying power particularly as the corporatization has affected the nature of the medical profession (Goldstein 1984; Relman 1985). Yet, autonomy over the work performed, an aspect argued by Freidson (1968), is a necessary element but not sufficient to provide dominance. A second element is the authority over someone else's work. The credibility of the professional title is paramount as the market becomes more competitive and as physicians begin to "unbundle services from hospitals and turn their offices into capital-intensive ambulatory centers for diagnosis and treatment" (Light and Levine, 1988, p. 20).

The medical profession has centralized its own authority by using "state powers throughout its history to pursue its goals and feared state intervention as a threat to professional autonomy" (Light and Levine 1988, p. 23). Indeed, the valorization of professional thinking and the investiture in professional titles can be in direct conflict with the typical functioning of a hierarchical bureaucracy.

In a professional bureaucracy in which standardization tends to be agreed upon and then imposed on the professional organization, the "coordinating mechanism is the standardization of skills" (Mintzberg 1980, p. 333). Conflict arises within professional organizations when there is lack of agreement concerning "professional values and interests" (Bucher and Stelling, 1969, p. 8), where the first one is characterized by overlapping work spaces, and the second one refers to the influence of administrative policy. Because a professional organization relies on standardization of skills that are transferred in specific roles and tasks as defined outside of the organization, the power to determine policy cannot be pinpointed to a specific position. It is

dislocated and the "balance of power shifts in response to different issues and as different persons and groups move through the organization" (Bucher and Stelling 1969, p. 11). As a result, debates and struggles over the locus of power occupy a great deal of time and energy in situations where there are multiple professionals with overlapping spheres of work.

Professionals and the institution are closely connected to each other. Where the professional draws on autonomy as an essential defining feature, the institution relies on a level of standardization, agreed upon by the professional association outside of the hospital, to provide a predictable level of care. It is a semi-dependent relationship. As Light and Levine (1988) point out in their discussion of the corporatization of the hospital and the proletarization of the staff (McKinlay and Stoeckle, 1988), as the institutional authority grows, professional authority can be either extended or put under threat. The authors further remark that in the conditions whereby a professional is reduced to a proletarian role within a corporate structure, the professional will defer their autonomy in favor of the goals of the institution. Nonetheless, the source of the legitimization of the institution comes from the professionals themselves (Light and Levine 1988, p. 19-20). As such, the professionals must maintain a fine line between deferring to the ideals of the institution and protecting the integrity of their professional status upon which the status of the hospital relies.

Besides all the clinical and medical aspects that a hospital is involved in, the administrator is the person who is supposed to handle all administrative aspects of all the activities within the hospital. This also includes the coordination between the different stakeholders in such a manner in which all come together and are able to tend to a patient in the most proficient way. This task is one of the greatest challenges of the hospital as it is supposed to mend and bend in a very cohesive fashion all the actors and stakeholders' demands, concerns and goals, taking in consideration each social factor which affects and influences all those involved in the hospital.

Differences in the triad actors

The administrator not only serves as a power figure, but he also moderates and intervenes where necessary; in essence, his role is more of a manager of affairs rather than that of an executive. For McKee (1970, p. 29), the administrator is "a true *man for all seasons*." Using a previous definition of Vanderwarker (1967, p. 39), McKee (1970, p. 27) defines the hospital

administrator as “he who must -be concerned with the institution as a whole, the activity it supports, the public face it presents, and the private activity with which it is occupied.”

Therefore, different levels of administration and coordination are required.

The role of administrators has evolved over the years, allowing them the experience to make both financial and managerial decisions in such a way as to avoid side-effects. Furthermore, this also helped their ‘legitimization’ vis-à-vis the medical profession, and their understanding of the different rationalities involved in the decision making processes concerning healthcare in general (Perrow, 1961). Consequently, the medical spectrum is captured under the command and control of administration.

There are different problems and dynamics present in the interaction between the administrator and physicians as articulated by other researchers. Eakin (1984, p. 222), through a small survey of the literature, states that there are three main reasons why there is discrepancies and difficulties for the administrator to ‘manage’ the medical staff: status differences, physicians’ claim to clinical autonomy, and the latter’s ‘contractual’ position with the hospital.

According to Wilson (1963), the most simple and convenient manner to understand the social structure is to examine the interpersonal relationships and subsequent actions which are centered upon those particular nexuses. Problems with beliefs and attitudes, and issues with the social structure are the two foremost reasons why social and cultural aspects hinder effective team work (Peeples and Francis 1968). The natural tension which exists between the doctors and nurses is brought upon by the difference in skill, talent, learning, education, training, job requirements and attitudes towards the other party. Despite the significant dissimilarity among the two occupations, nursing staff assumes that the physicians are not only aware but also understanding of the scope and sophisticated aspects of their profession. Likewise, doctors believe that nurses are acutely aware of the needs of patients, and can appreciate the requirements of the job they have and can relate to the former.

Peeples and Francis (1968) state that there is a need to target the area of breach amongst the doctors and nurses, which are caused by the differences in values, attitudes, beliefs. The main disparity is in their classes; while the doctors tend to come from higher classes of the societies, nurses typically belong to middle or lower-middle classes. Varying classes of origin can also have an impact on their dissimilar beliefs and attitudes, which constitute for different viewpoints about the general perception of medical and healthcare.

In the *Income Breach* section, Peeples and Francis (1968) showed that there is a big disparity of income between doctors and nurses, a key element in contributing towards social differences. Physicians typically spend 9-12 years for education after high school, which is a lot more than a 4 years degree the nurses hold. However, the overall time spent is $1/3^{rd}$ for nurses, on average, yet the income disparity is as high as $1/5^{th}$ of what the physicians earn. To further build on the same point, the difference in status assigned to doctors and nurses is directly linked to the occupational gap. Physicians enjoy the most esteemed position in society, whereas the nurses are low on the hierarchical ladder in society (Peeples and Francis, 1968), lower than is deemed necessary by their qualification and importance of their work. Hence, nurses often view the doctors enjoying a far greater prestigious life, and which can cause them to develop 'status anemia'. Relative inequality between doctors and nurses, when viewed from the perspective of an egalitarian society breeds many in-house conflicts, including issues regarding lack of motivation and enthusiasm on the nurses' part. This is also very closely related to the occupational identity struggle.

According to Peeples and Francis (1968), the profession of nursing is being further demeaned by the additional sub-division of labor, women's status in healthcare, and rapid socio-cultural changes. This is in fact, unfair to the entire profession, as the nurses' duties are complicated with the advances in technology, and they are not being given enough credit for their competent work. Nursing tasks can often be overlooked as routine and simple, requiring less specialized approach. On the other hand, the suggestions and involvement of doctors is thought of substantially more important, in the eyes of the patients.

Expectations states theory describes how status formulates a power hierarchy, which is a contributing factor in status differences (Berger et al., 1998, Ridgeway, 1994). DiTomaso et al. (2007) also mention the importance of power groups within an organization, and relate it with expectation state theory. Status construction theory suggests a direct link among resources and competence – the assumption of this association means that those with higher status are more confident, and in a way, widen the status differential with the lower status group (Ridgeway, 1991; Ridgeway et al. 1998).

METHODOLOGY

The research was performed at one major general hospital in the Montreal region which provided historical archival data of surgeries performed during a three year period. Furthermore, different interviews were performed with the surgeons, administrators, and OR nursing staff of the hospital. The interviews performed provide the details of what the OR scheduling procedures are and how they take place, as well as the interactions between different surgical units.

As the (average) durations of surgeries differed between units, it was assumed that their planning methodology might be different. There were 12 interviews performed were with the staff of the 5 surgical units, out of a total of 11 surgical specialties of the entire hospital, which are: Cardio-Thoracic-Vascular (C.T.V.) surgical unit, Ear-Neck-Throat (E.N.T.) surgical unit, General surgery, Neuro-surgery, Ophthalmological surgery. The Cardio-Vascular surgical unit was combined with Thoracic surgical unit in this analysis due to the historical surgical information provided by the hospital, thus forming the Cardio-Thoracic-Vascular surgical unit. The two reasons why these 5 specific units were chosen is that the average surgical durations for each unit have a great variability, and that the number of surgeries performed by each unit is different. This provides good insight for the quantitative simulation analysis.

The staff interviewed included Chiefs of units, surgeons, nurses, and administrators. It must be noted that the unit chiefs, even though they are surgeons themselves, have an administrator's role as well. Furthermore, interviews with OR nurses and booking department were also performed in order to provide a clear picture of the scheduling performed in this particular hospital as well as to understand the coordination efforts required to create the Master Surgical Schedule. There were a total of 5 hours and 22 minutes for the interviews that were transcribed in a total of 96 pages. The main questions asked are provided in Appendix C, segregated by the role of the interviewee.

Table 4 provides the number of surgeons within the specific unit, the number of staff interviewed and the number of surgeries performed by each individual unit that is part of the

	Number of surgeons	Staff Interviewed	Number of surgeries
C.T.V.	14	2	618
E.N.T.	8	3	629
General surgery	14	3	635
Ophthalmologic surgery	11	1	1,639
Neurosurgery	2	1	203

Table 4: General characteristics of 5 surgical units

research. Table 5 shows the number identification of the interviewee as well as the position(s) he or she holds. More information cannot be provided for Table 5 in order to protect the confidentiality of the interviewees.

	Position		
Interviewee	Surgeon	Administrator	Nurse
1		X	
2		X	X
3	X	X	
4	X		
5		X	
6	X	X	
7		X	
8	X	X	
9	X		
10	X	X	
11	X		
12	X		

Table 5: Interviewee's positions in the hospital

There was only one interview with an OR nurse; this is due to the lack of time that OR nurses have outside the OR. Even though the interviewee has a high administrative position, enabling the nurse to be aware of potential tensions between OR nurses, surgeons and administrators, it is only just one perspective of these professionals and it is considered not representative. As additional inferences could not be extracted for the qualitative aspect of the research, the nurse's interview is not included in the analysis.

The principal quantitative analyst of the hospital provided some of the initial contacts by introducing the researcher to some of the units. Emails were sent to the Chiefs of the units requesting an interview. At the interviews with the chiefs, the snowball sampling technique was used as the chiefs were asked if they recommended other surgeons within their units for the study; once the potential surgeons were identified, they were sent an email inviting them to the interview. The same procedure was used for the unit administrators. In all the first emails sent to the potential participant, the following documents were included: the lay summary of the study, the questions, and the information and consent form. The participants had the opportunity to choose the time and date of the interview.

The interviews were open-ended in order to allow for more spontaneous responses, permitting the interviewees to provide their direct input and their perspectives into the subject matter.

Open coding was used by analyzing each paragraph of the transcribed interviews. The interviews were performed to uncover 3 fundamental aspects: 1. an understanding of how the elective surgery schedule is created; 2. interactions between stakeholders and their characteristics; 3. how do stakeholders see a potential centralization of the elective surgery

schedule. These were also the main categories that were used to identify different factors of the operations within a specific unit.

The primary codes were larger in number in order to be as faithful to what the interviewees reported. Some of these codes were redundant, thus they were collapsed. The following step comprised in the interpretation of the codes, and provided the secondary categories codes, the overarching themes. Once the themes were developed, the data was organized by classes of interviewees as well as by the units under study. The categories that were used are provided in Appendix D.

The interviews provided information related to the manner in which ESs are scheduled in the hospital. Secondly, the interviewees are able to ascertain, from their perspectives, if the current decentralized scheduling is working to the standards that these professionals aspire to. Thirdly, if there are any improvements to the scheduling system, they are able to ascertain them, as well as the implications related to the implementation of a centralized scheduling system for ESs.

The interviews' analysis is performed in the following manner: 1) the interviews are firstly segregated by the different units; 2) a different separation is also provided by combing the opinions of the specialists within their own profession, i.e. surgeons and administrators; 3) another section is provided by revealing the interviewed professionals' opinion on the current scheduling system, as well their opinions regarding a hypothetical centralized ES scheduling method; this also includes the interviewees' opinion on the current hospital administration.

The quantitative aspect of the research refers to different computer simulations of a centralized scheduling system. There are 3 centralized scenarios, with different characteristics, that are used to compare the output results with the historical data provided by the hospital.

Historical surgical data of all elective surgeries performed within a period of 3 years was requested. It represented 27,684 entries and the data was extracted from the hospital's OR schedule system. It included the information presented in Table 6.

Patient ID
Surgical unit
Surgical ID request
Principal intervention(type of surgery)
Surgeon's ID
Date the surgery was planned for
Date and time when the patient arrived at the hospital for its surgery
Surgery estimated duration time
Surgery start date and time
Surgery end date and time

Table 6: Historical data requested

From this information, the actual duration of the surgery was calculated. The patients' appointment information for the same 5 different surgical units, i.e. date when a specific patient had its visits, was retrieved from the individual surgical units' database. There were 342,780 entries. The latter data was combined with the OR patients' ID information using a matching SQL (Structured Query Language) script. In case that a patient had multiple visit dates, the earliest visit date was chosen to determine the start of the waiting period of the patient's surgery.

After the data were combined and cleaned – missing information from either data sources – there were 15,109 entries. These form the total number of windows of opportunity surgeries (called Windows). The schedule used for the simulations has 27,462 entries (called 'the Wall'). The Wall represents all the surgeries which were performed by the hospital, regardless if there was a patient visit date or not.

The centralized simulation scenarios provide just a computational analysis. Comparing them with the actual historical surgeries performed during the same time period, one is able to have a proper assessment of the two scheduling methodologies. However, this analysis is incomplete without the evaluation of a centralized model by those involved in the planning and forming of the ES schedule, meaning the input of the staff that directly is affected and influences the schedule itself. As mentioned before, this is one of the key reasons why interviews with the hospital staff are performed.

The triangulation of the qualitative and quantitative components of the study is performed in such a manner that the comparison between the simulation results and historical data are interpreted by the different perspectives that the interviewees provided, coupled with theoretical standpoints presented in the literature review.

Even though waiting time for ES and its reduction is the topic of this research, this aspect has important implications for all the hospital. Many elements are affected by reducing or increasing the patients' waiting time. This is why other indicators, such as idle OR time, OR overtime, rescheduled surgeries, are also vital in order to have a clear analysis if a centralized scheduling method or a decentralized one is able to respond better to all the stakeholders' requirements.

Overall qualitative results

In order to provide a better picture of how the hospital works and provide the view of different staff categories, the following section explains firstly what is important for surgeons' perspective, and secondly different aspects that are eminent for the administrators. As previously mentioned, this information offers the staging of the research question as not only the opinion of the different staff interviewed is segregated by the interviewee position, but also it describes how booking is performed in the hospital, the interviewees outlook of the hospital administration regarding OR scheduling, as well as their estimation and attitude towards the idea of centralizing the ES scheduling system.

Surgeons

Even if there are different methods in which OR time is scheduled to individual surgeons, all surgeons would like more OR time. It must be noted that surgery booking and especially performing surgery is highly tied to the surgeon's remuneration.

The surgeons are responsible for the scheduling and rescheduling of patients. They base their decision on the diagnosis of the patient. It is rare that patients are shared, expect in cases of emergencies, because the patients develop trust and history relationships with the surgeon.

Even though there are tensions at times between surgeons and nurses, these do not affect what happens in the OR. For the entire team who is performing the surgery, the patient is the first priority.

Most surgeons have a full OR day allocated to them. However in the cases where an OR is split/shared, most surgeons are considerate and avoid, to their best capabilities, not to go over the time allocated. Having a dedicated OR to the surgeon ensures that there are no tensions between surgeons because one took more time than necessary; however, if it does happen, the surgeons who lost some time show forbearance and leniency. The same is applied for emergency cases. A good gesture if the surgeon who entered an OR with an emergency case would be to give latter on OR time to the surgeon who lost the time. Sometimes this happens, but not always.

Different units operate differently, as some share the patient list (1 unit out of the 5 units interviewed), some have access to two ORs in the same time, thus reducing the changeover time, some use a high efficiency day (1 unit out of the 5 units interviewed), units and surgeons take in

consideration the patient and priority is given to the patient. This might create certain tensions between surgeons during the emergency-flex OR time as each surgeon fights for their own patients and that specific patient is more important than another.

The estimated surgery times are dependent on the surgeons and on the procedures which are performed. As being a general hospital, and thus a teaching hospital, if there is teaching in the OR, may it be for residents, nurses or anesthetists, the surgeon is affected for their future surgeries. Most surgeons are understanding and support the teaching aspect of the hospital by communicating more to the nurses. The booking administrator tries to provide as much flexibility to the surgeons for their estimated surgeries as he can. Yet, in the end, the rhythm of the surgery, even if it is imposed by the surgeon, it is also dependent if there is any type of teaching happening in the OR.

Some surgeons prefer to refer patients to another surgeon as their own waiting list is large. Once again, the patient is the priority. If the waiting lists are not properly managed, it creates a monster that is very difficult to manage.

All the interviewed surgeons believe that OR time is capped due to budgetary reasons. Thus, if the budget of the hospital would increase, and more nurses, anesthetists, equipment would be present, more surgeries could be performed and thus, reduce the waiting lists. The government, through different programs did increase the budgets for specific categories of surgeries.

Surgeons are underutilized. They almost work part time (Interviewee 6). While the surgeons understand that the hospital has priorities, sometimes it is felt that there are too many priorities. Furthermore, the hospital's interests are not the same as those of the surgeons.

Most nurses have multiple skills and are cross trained, while some nurses are highly specialized, especially in the cardiac team. It is important for the surgeon to know who is available, OR nurses wise, in order to have a specialized team and the best available team. If there is no specialized team, a surgery can be postponed to a later date.

Administrators

The unit administrators want to serve the unit in which they are. They are the *middle man* between the units and booking. Thus, there are no tensions between the unit administrator and surgeons as the former provide services to all the surgeons within the unit. The unit administrator

is to be considered an employee of the unit. At the same time, there are no intra or inter unit tension between the administrators of the unit and other staff, as reported in the interviews.

It must be noted that there are 3 main schedules that come together: OR, nurses, and anesthetists. These are required to be synchronized in order to have few cancelations due to missing resources, may those be staff or equipment. Better integration of resources would provide the administrators with greater ability to provide services to the units.

The administrators of the units only use the resources that are available to them. In order to schedule a surgery in most cases, the patient is required to have pre-operative testing, which may include also different types of scans. Certain patients have their scans done outside the hospital due to a very long waiting for the scans within the hospital.

Some units use a category priority scheme to prioritize their surgeries. This is useful to decide the 'maximum' waiting time that a patient is entitled to. However, there are a lot of grey areas between the categories, especially between the first two priority categories.

Each unit will fight for their own patients, but everyone understands that the organization has memory, and long lasting relations with any of the units where there is an interaction is desirable; in other words, all units want to have good relations with the other units..

Surgical categories are a grey zone and some surgeons attempt to game the system. However, the OR staff is able to see the misalignments and a surgeon can get a 'bad reputation' because of this.

Even though emergency-flex time is used to reduce the surgeon's waiting lists, and reschedule the booted patients, there are tensions between the surgeons regarding the priority of the patient. Emergency-flex time is considered as extra OR time, with the understanding that an emergency would have priority.

There is room for improvements on the administrative side of the hospital. Common knowledge is essential between the staff of a specific unit, but also when information is required by another unit. Moreover, the administrators do not have all the patients' waiting list.

All surgeons know that the nurses' overtime costs a lot to the hospital. Also, all the surgeons do not like to have canceled surgeries.

OR administration/booking

There is only one booking agent for the entire hospital. It is his responsibility to make sure that all surgeries are booked, meaning that each surgery needs to be properly estimated in duration and verified with the surgeon. The estimated surgery time is provided by the booking program, using the average of the last 10 procedures (of a surgeon); yet, times are manually adjusted because the average time is calculated on the first procedure (which most of the time overestimates the entire surgery). The booking agent calls the surgeons in order to verify the duration of the surgery and adjusts accordingly. The average times for a specific surgeon are quite accurate, but they vary from surgeon to surgeon. However, some surgeons believe that the hospital scheduling system does not work well.

It was also mentioned that changeover (another aspect that booking agent must take in consideration) may be long in bloody cases; these involve a lot of patient bleeding. This affects the next surgery as it cannot start until the OR is sanitized.

There is a good relation between booking and surgeons. Yet, there is, in a way, tension between surgical units as all units would like more OR time.

All surgical units receive a draft schedule, including OR nursing and anesthetists. The last two units build their own internal schedule based on the draft schedule provided by booking.

The draft schedule is done 7 days in advance. Besides vascular and neurosurgery where the cases are booked 48 hours prior, all surgeries are booked 7 days in advance. For these 2 units, the block times are always there. Furthermore, out of the 16 ORs, only 12 are functioning due to lack of nurses. During vacation and summer, there are only 8 ORs in use.

There are swaps between surgeons, however, the booking agent needs to be contacted in order to make sure that the right equipment is in the OR and ready for use.

There is a lot of bureaucracy in booking, including a lot of red tape. Most of the work is done in silos and because of this, there is a lack of harmony due to communication scarcity. Decision made within a unit affect the OR schedule. The booking administrator is not the information hub. Information goes around the booking agent, but in the end, it filters in. Because of this, the schedule needs to be redone as either there is the wrong information or information is simply not there. The information that the booking agent should always have on-hand include the availability of mechanical instruments, such as portable scanners, C-arms and C-arms tables, schedules of the surgeons, OR nurses, anesthetists, including specialized teams, respiratory

technicians and other technicians, availability of beds prior the surgery, availability of ICU beds, special equipment requested and required by the surgeon to perform the surgery, including specialized surgical instruments.

If there is an emergency, everything shifts. Moreover, if there is a cancelation, that OR time is wasted unless there is an emergency that comes in. Additionally, if there is an opened OR at the end of the day and there are no emergencies, that time is lost.

Even though cancelations occur, they are not under the control of any direct unit: lack of OR nurses, no ICU beds, or previous surgeries taking longer than expected. When cancelations do happen, the unit staff is frustrated and the OR time lost does not come back to the unit that lost the time. All rescheduled patients wait less time for their 2nd scheduled surgery.

Hospital administration

Waiting time in Quebec is long. The government imposes certain guideline or benchmarks. For example, all cancer patients should receive their surgery in 28 days; knee and hip surgeries should be performed within 6 months. This is important as the government allocates different budgets to what it deems a priority. If a surgical unit becomes a priority for the hospital, then that unit would have more resources allocated to it. Thus, it is a question of what is the priority of the hospital and of budget.

The internal scheduling system has its benefits, but also its pitfalls. If a surgery takes longer because it is a 'teaching surgery', meaning that either the surgeon, nurses or anesthetist are teaching, the surgeon is *penalized*: the duration of the surgery will be in the system and it will affect his future estimated times. The teaching ORs are not taken in consideration in the estimated times and the surgeons get penalized in the long run because of it. This aspect is valid for all surgical units.

There are other problems with the scheduling system. Most surgeons would like to have more input regarding the estimated times of the surgeries. The surgeons do not dismiss the computerized system; they just would like to have some weight assigned to the surgeon 10%-25% allocated to the surgeon and 75%-90% allocated to the system.

The booking administrator does a good job shuffling surgeries depending on the resources/equipment which are required. However, more transparency and higher levels of communication and data transfer would be required in order not to lose too much time building

and rebuilding an OR schedule. The equipment is not always updated on the OR schedule which causes problems in the perfect allocation of resources for a specific surgery. If the equipment is not in the OR, the surgery gets delayed, thus delaying all subsequent surgeries; this may also result in cancelations at the end of the day.

High efficiency days, as performed by E.N.T. could resolve certain issues. However, these type of intense surgical days could only work for surgeries performed by urology and ophthalmology, where the surgeries are 'repetitive', meaning it is the same procedure and there is a low chance of complications during the surgery. The idea of having two ORs, two teams and one surgeon is also appealing as it reduces the time that the surgeon waits between surgeries. This type of setup would be beneficial to similar surgeries which do not require a lot of time to be performed. However, the hospital is interested in the efficiency of the institution not that of individual units (Interviewee 10).

Other problems that the hospital has include the fact that there are a lot of referrals that come in from other hospitals and these referrals are given priority. Furthermore, during the summer and vacations the OR time is cut by 30 %. The patients are the first ones affected as well as the hospital staff. Also, the nurses' shortage and more OR time are the major impediments that the interviewees mentioned on multiple occasions.

In most cases, access to OR is easier than access to other resources, such as radiology (ultrasounds or MRIs). Some patients prefer to spend 150$ for their scans instead of waiting 6 months for them in the hospital. There are cases where units cannot abide by the government's rule of 28 days surgery for cancer patients. Additionally, if a patient is waiting too long, most of the time the patient goes outside the hospital to have his surgery.

Centralization and other issues

The interviewees are partially divided regarding the use of a centralized system.

A better and more flexible method of calculating the estimated duration of the surgery is required. Better variables/indicators are needed. It is a good idea to see all the patients in the same time and to prioritize them under the same rules, with the same information (Interviewee 12).

Centralization would be beneficial for surgeons who have a lot of variability in the surgical times. Centralization would also provide a better integration of resource management.

This might not only be limited to what equipment is required for a specific surgery, but also downstream, such as availability of ICU beds. The centralized system should consider all the resources required for a surgery as there is a misalignment between OR room, OR staff, ICU beds, equipment. This also includes the schedule of the surgeons as all of them would like to have full OR days for different reasons: dedicated OR day; a surgeon is more efficient if he is in the same place; coming in and out of the OR multiple times during the day would be stressful and time would be lost; split ORs would create additional stress and tension between the surgeons because they need to be finish 'on time'. One of the main questions is how the centralized scheduling system would allocate the OR time.

If the patient is in the middle of the system, centralization would be good for the patient, but not necessarily for the surgeon. Surgeons are not only performing surgeries. They have other responsibilities, such as clinic hours and working on-call. Their schedule should also be taken in consideration if a centralized system is to be implemented. At the same time, nursing and anesthetists schedules should be included in the same system.

Rescheduled patients should be done in the morning in order to ensure that they are not booted again. Also, specific algorithms should be used for the diagnostic that would determine the wait time, thus the time when the patient receives the surgery.

However, the system should have the possibility to be manually adjusted. The booking administrator should be the hub of all information and all information should come directly to him. From an administrative point of view, less bureaucracy is needed in the use of a centralized system and an increase of communication. Work needs to not be done in silos.

"The ultimate [goal] is to get the patient operated on" (Interviewee 5).

Centralization may not work as all the cases are different. The centralized planning system and the person creating the schedule do not know the entire story behind each case. "You treat the person, not just the diagnosis" (Interviewee 7). Shared patients is not a good idea for the reasons previously mentioned.

Centralization would not work as it requires additional information such as what happens in the personal life of the patient, work life (Interviewee 8). Centralization "loses the human touch" (Interviewee 8). Not everything can be digitized, included in a computer system (Interviewee 8). Every diagnostic is different.

Peripheral knowledge, medical information that is not directly relevant to the patient's surgery, does not change how a surgery is performed. Therefore, the information included in the system needs to be carefully considered a-priori. At the same time, if centralization is to be implemented, it is important who decides the rules of the schedule (Interviewee 12). It was noted that the financial agenda is different from the surgeons' agenda which is different from the patients' agenda (Interviewee 12). In order to reduce the waiting list, more resources (OR time) is required and not necessarily a centralized booking system. The number of surgeries has to be maximized, but within a certain budget (Interviewee 12).

It is believed that one of the problems with centralization is that some surgeons might have more OR time while others might have less.

Central booking may be more efficient on paper but not in reality (Interviewee 10). Furthermore, centralization would have too many details to manage (Interviewee 11). Moreover, centralization is not beneficial for units that have a low variability and few patients.

Quantitative setup

Simulation and optimization

According to Banks et al. (2005, p. 3), "a simulation is the imitation of the operation of a real-world process or system over time." The simulation model comprises of the system's behavioral changes over time. Many researches, from Naylor et al. (1966) to Shannon (1998), have found certain situations when simulation is an appropriate analysis tool, described by Banks et al. (2005, p. 4):

1. Simulation enables the study of, and experimentation with, the internal interactions of a complex system or of a subsystem within a complex system;
2. Informational, organizational, and environmental changes can be simulated, and the effect of these alterations on the model's behavior can be observed;
3. The knowledge gained during the designing of a simulation model could be of great value toward suggesting improvement in the system under investigation;
4. Changing simulation inputs and observing the resulting outputs can produce valuable insight into which variables are the most important and into how variables interact;
5. Simulation can be used to experiment with new designs or policies before implementation, so as to prepare for what might happen;
6. Simulation can be used to verify analytical solutions.

One can realize that some application areas of such tools could be found in manufacturing, construction engineering, project management, military, logistics, transportation, business processes, and not the least, health care. At the same time, simulation is a good approach to evaluate and measure the objective function value by multiple replications of the system, thus providing more information. One of the major benefits of using simulation models is the overall low cost of system design changes and their evaluations. However, it must be noted that these simulation models only evaluate the systems under study – they do not improve them.

According to Forester (1980), simulation can be a very useful tool to examine and explain dynamic systems that are too complex for mathematical modeling. Levit et al. (1999, p. 1482) provide a very simple explanation for this:

> Model based simulation best represents the dynamic behavior of actual complex organizations because relevant objects – activities, participants, messages, meetings – from the real world are specifically represented by corresponding software objects with defined properties and behavior in the model.

The current model can be considered as discrete events modeling as specific actions are taken at specific times via different rules. However, the model can also be thought of as an agent based model as the actions of one element (OR surgery planning) affects all the other elements. For this reason, the overall model falls under a hybrid methodology where both discrete models and agent based models converge and are combined.

Furthermore, the main goal of optimizing simulation results is to find an optimal solution of the simulation model. Such a design requires multiple runs of the simulation. In the present case, there were 30 runs (30 simulations) for each of the three scenarios analyzed. For very complex optimization situations, especially for those in which the objective function cannot be identified directly or when there are multiple objective functions each with their own weights, which is the case in the present analysis, simulation provides the necessary answers in regards to the main objective function.

It must be noted that the more detailed the model, taking in consideration many variables, parameters and objective functions, the heavier the burden on the computer's CPU. This requires longer processing time, yet it provides more realistic results. The average running times for the simulations used for this research are provided in Table 18.

The current model can be characterized as a deterministic model because the parameters (coefficients) that are fed in the optimization are deterministic, i.e. no stochastic elements are used. At the same time, the manner in which the optimization is performed, via genetic algorithms, the model is using a meta-heuristic method. Therefore, there are elements that are both deterministic in nature and others that are stochastic. This is another reason why multiple runs are required.

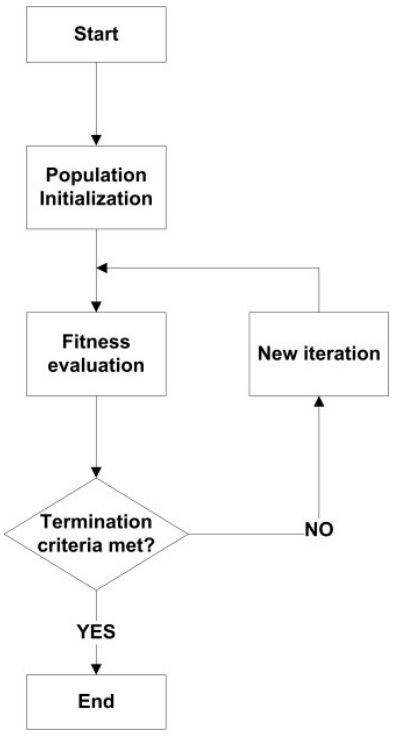


Figure 3: Genetic algorithm flowchart

Genetic algorithms (GA) are a subclass of evolutionary algorithms which use a search technique that imitates the biological evolutionary processes. A solution is called an *individual*; there are many individuals in the search space, where the set of solutions is called a *population*. Through an iterative development, new individuals are generated using random mutation and/or crossovers functions from the individuals present in a given population. Each iteration is called a *generation*. Natural selection ensures the best fit individuals of the current population will participate in the new population; this is accomplished as a higher quality of a solution would have a higher chance to survive and be selected. Figure 3 shows the generic process.

Having a multi-objective optimization problem, the goal of the genetic algorithm is to find the solutions with the best fitness, which is determined by the different objective functions. Deb (2001) showed that evolutionary algorithms are very effective at finding solutions to multi-objective optimizations due to the multiple population iterations process.

Genetic algorithms optimization was used as a global search method for the optimal solution. This approach avoided finding local optima that could miss out the optimal optimum. Furthermore, it also ensured that as the problem is not linear in nature, this would not be of concern. Having multiple objective functions, this analysis cannot be performed using MS-Excel through the 'Solver' add-in. For these reasons, a tailored optimization program was developed in Java using IntelliJ Idea v. 14.1.5, having the following interface:

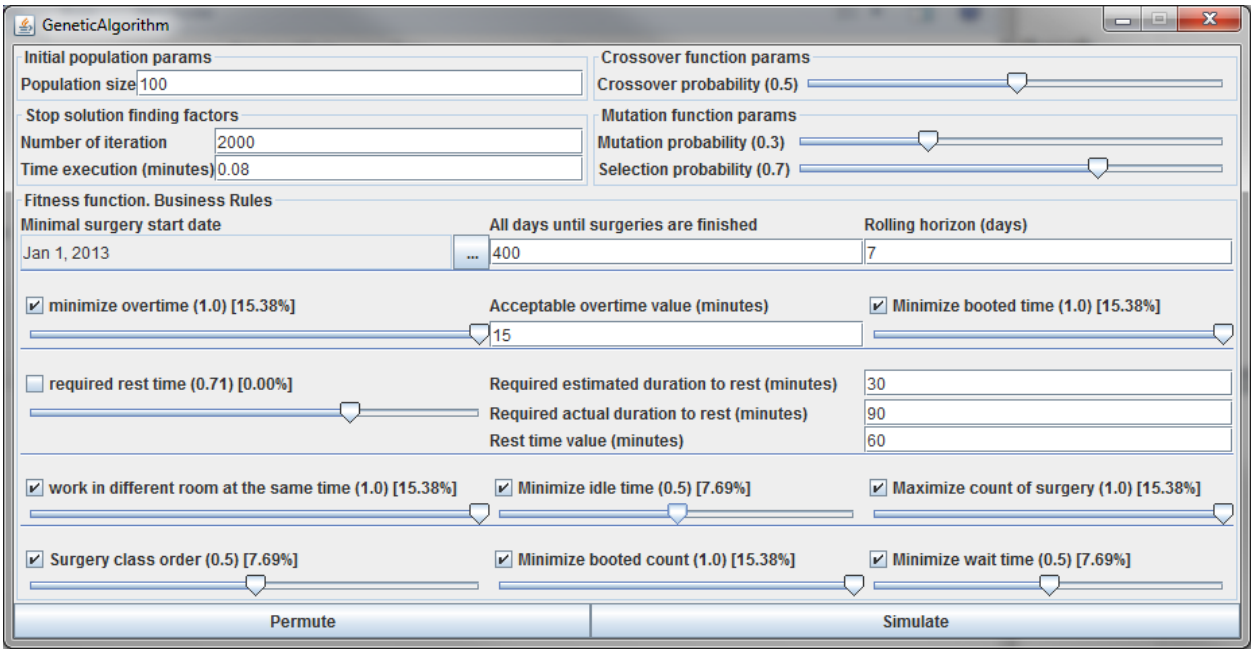


Figure 4: Interface of simulation program

There are 6 objective functions that need to be optimized: 1. Minimization of overtime in the OR; 2. Minimization of idle time in the OR; 3. Minimization of booted surgeries; 4. Minimization of booted surgeries time; 5. Maximizing the number of surgeries; and, 6. Minimization of patients' waiting time. There are also 3 important rules: 1. Rest for surgeons between surgeries; 2. The ability for a surgeon to work in 2 ORs at the same time; and, 3. Making sure that longer surgeries are scheduled in the morning. The program is built in such a manner that each objective function and rule has its own weight and the user has the choice to change them; this also includes the choice of not including specific objective functions in the simulation-optimization (a weight of 0.0).

As previously mentioned, each surgery has its own 'estimated duration', provided by the internal hospital system. It is this value that is used to calculate the schedule. However, in reality, surgeries take longer or shorter time. The subsequent surgeries are dependent on the 'actual duration' of the surgeries during a specific day. For example, if a surgery is planned for 8:00 AM and it is intended to take 1 hour (having an ending time of 9:00 AM), the following surgery can start only at 9:00 AM. If the said surgery takes only 45 minutes, the following surgery will still start at 8:45 AM, and the OR would not have an idle time of 15 minutes. However, if the said surgery takes 1 hour and 20 minutes, then the following surgery can start at 9:20 AM; hence, it

starts late. This is important for surgeons and patients as well. Between each surgery there is also a 'change-over' time: cleaning the OR and preparing it for the next surgery. This change-over time is not included in the current model as there is a very high variability for it. Change-over time can take from 7 minutes in E.N.T. High Efficiency Day to 45 minutes when some cases are bloody. The change-over time is dependent on the surgery itself, and this information is not known in advance. The historical data provided by the hospital did not include the change-over time.

Optimization rules

The simulation model is defined using the notation presented in Table 7.

Assignment	**Room**
vt - visit date (minutes)	*sr* - operating room start time (minutes)
sa - assignment start time (minutes)	*er* - operating room end time (minutes)
ea - assignment end time (minutes)	*aot* - acceptable overtime (minutes)
sap - assignment initially planned start time (minutes)	*R* - count of operating rooms
eap - assignment initially planned end time (minutes)	
Chromosome	*n* - count of genes in chromosome (length)
Genes	
Historical surgery start	Patient ID
Historical surgery end	Surgical specialty
Actual surgical duration	Visit date
Number of times rescheduled	Surgeon ID
Number of times booted	Surgery ID
Historical wait time	OR ID
Simulation wait time	Estimated surgical duration

Table 7: Notation of the simulation model

Using this notation, the mathematical formulation of the objective functions and rules is then provided.

Minimize overtime. Description: Making the plan with using minimum overtime minutes. The acceptable overtime value is the number of minutes that surgery can be scheduled over the availability of a room.

Assignment overtime value: $ot_i = \begin{cases} ea_i - er, & if\ (ea_i - er) > 0 \\ 0, & otherwise \end{cases}, i = \overline{1,n}$

Rule value for gens: $p_i = \begin{cases} p_{i-1} * ot_i, & if\ p_{i-1} > 0\ and\ ot_i \geq aot \\ p_{i-1} + ot_i, & otherwise \end{cases}, i = \overline{1,n}$

$Rule\ value\ = p_n$

Work in different rooms at the same time. Description: The rule ensures that there is no possibility that two surgeries are planned in the same time in the same OR or two surgeries overlap.

$$Rule\ value = \sum_{i=1}^{n} \begin{cases} (ea_i - sa_i), if\ assignment\ i\ intersects\ with\ surgeon's\ other\ assignment \\ 0, otherwise \end{cases}$$

Minimize idle time. Description: This rule minimizes the idle time of an OR.

OR free time:

$$ft = (er - sr) - \sum_{j=1}^{m} (ea_j - sa_j), where\ m\ is\ count\ of\ already\ planned\ surgeries\ in\ OR$$

$$Rule\ value = \sum_{j=1}^{R} (ft_j - \sum_{i=1}^{n} \begin{cases} (ea_i - sa_i), if\ assignment\ i\ belongs\ to\ OR\ j \\ 0, otherwise \end{cases})$$

Maximize count of surgery. Description: The rule inclines the GA to use as many surgeries as possible in the schedule in order to increase the variety of solutions.

$$rule\ value = \sum_{i=1}^{n} \begin{cases} (ea_i - sa_i), if\ surgery\ is\ not\ included\ in\ schedule \\ 0, otherwise \end{cases}$$

For example, a new day schedule is created. A set of surgeries from the unscheduled queue are to be scheduled:

1	2	3	4	5	6

Each surgery may be in two states {SELECTED; NOT_SELECTED}. If it is in the NOT_SELECTED state, then such surgery would not be included into the schedule of this day:

1	2	3	4	5	6

In this case, surgeries 1, 3, 4 are scheduled and 2, 5, 6 are not. 2, 5, 6 are included again in the queue and may be scheduled in next iteration.

Surgery class order. Description: The rule sequences the surgeries depending on their estimated duration class. The classes are presented in Table 8.

$$Rule\ value = \sum_{i=1}^{n-1} \begin{cases} (ea_i - sa_i), if\ surgery\ i\ class\ is\ lower\ than\ surgery\ i+1\ class \\ 0, otherwise \end{cases}$$

The model attempts to mimic the reality of elective surgery scheduling, taking in consideration that longer surgeries are planned to occur in the beginning of the day. These were broken into classes, as shown in Table 8. Furthermore, part of the optimization procedures, there is a punishment function included. For example, if surgeries of categories B, C, C, D would be the optimal solution for the surgeries to be scheduled, and the optimization algorithm would present a solution in the form C, D, C, B, the latter option would be punished, having a lower value in comparison with the B, C, C, D solution. The same is valid for all other objective functions which do not perform well, i.e. not being a 'good fit'.

Class	Lower bound (h)	Upper bound (h)
A	4	6
B	3	4
C	2	3
D	1	2
E	0	1
SPECIAL	6	no bound

Table 8: Surgical duration classes

Minimize booted count. Description: This rule minimizes the surgery date change count; it punishes the chromosome with not-planned surgeries which were previously rescheduled.

$$Rule\ value = \sum_{i=1}^{n} \begin{cases} (ea_i - sa_i), if\ surgery\ was\ booted\ off\ and\ not\ included\ in\ schedule \\ 0, otherwise \end{cases}$$

The difference between a *booted* surgery and a *rescheduled* surgery is the following: a rescheduled surgery is a surgery that is shifted at least once during the same day. A booted surgery is a surgery that was scheduled in a specific date, however due to previous surgeries that took longer, this surgery does not fit at the end of the day.

Minimize booted time. Description: Rule that minimizes the time between the surgery's initially planned date and the same surgery booted date. The chromosome is rewarded if the booted surgery is selected to the plan.

Booted time (days): $bt_i = \frac{(sa_i - sap_i)}{24*60}$

$$Rule\ value = \sum_{i=1}^{n} (ea_i - sa_i) * (\frac{2}{1 + e^{-0.25 * bt_i}} - 1)$$

The 'booted' count only takes in consideration the Window surgeries.

Minimize wait time. Description: This rule minimize the waiting time of the patient for its surgery by summing the wait time of each surgery.

$$Rule\ value = \sum_{i=1}^{n} (sa_i - vt_i)$$

Fitness function. Description: It is the sum of all the weighted values for each rule. As shown in Figure 4, the weights can be selected by the modeler using the side bars. The numbers in round parenthesis represent the weight associated with the specific rule (0 to 1). The numbers in straight brackets are the normalized weights of the rules; this approach is easier for an analyst to compare the relative weights of the rules.

$$F(p) = min \sum_{i}^{rules} |rule_i.value * rule_i.weight|$$

There are four main steps in which the model works: 1. Execution; 2. Addressing shifts and booting surgeries; 3. Rescheduling surgeries taking in consideration the rolling horizon; 4. Provide next day computations.

Historical data analysis

The base line for the analytical comparison is the actual decentralized surgical waiting times of patients. These values are historical values of surgeries which took place at the hospital.

Table 9 shows the total number of surgeries performed by the hospital for a 3 year period. Table 10 provides only the number of surgeries of the

Surgical Unit	Frequency	Percent
Breast Oncology	858	3.1
Cardiac	1,314	4.7
Colo-rectal	1,007	3.6
Dental	154	0.6
E.N.T.	2,435	8.8
General surgery	2,790	10.1
Gynecology	1,776	6.4
Neurosurgery	674	2.4
Obstetrics	4	0
Ophthalmology	8,861	32
Orthopedics	4,236	15.3
Plastics	544	2
Thoracic	237	0.9
Urology	1,815	6.6
Vascular	979	3.5
Total	**27,684**	**100**

Table 9: Number of surgeries by surgical unit

surgical units under study and their percentage of all the surgeries performed by the hospital.

	Historical values	
Surgical unit	Frequency	Percent
Cardiac surgery	1,314	4.7
E.N.T.	2,435	8.8
General surgery	2,790	10.1
Neurosurgery	674	2.4
Ophthalmology	8,861	32
Thoracic surgery	237	0.9
Vascular surgery	979	3.5
Total	17,290	62

Table 10: Surgical units analyzed – Historical values

The patients who received cardio-surgery, thoracic-surgery and vascular-surgery were combined in one category: Cardio-Thoracic-Vascular (C.T.V.). The reason for this grouping is twofold: 1. the hospital already combined cardio and vascular surgical departments into one unit; 2. some patients visited one of the 3 specialty clinics, yet received the surgery in a different specialty (e.g. a patient visits the cardio surgery clinic and receives the surgery under thoracic specialty).

The five different surgical units which are used to provide the historical baseline for the current model are: C.T.V., Ear-Nose-Throat (E.N.T.), General surgery, Neurosurgery, and Ophthalmologic surgery.

Having surgeries for which waiting time can be calculated provides windows of opportunity. The Wall surgeries create the canvas on which the Windows are created. Once the windows are created, and empty slots in the scheduling are formed, the simulation program attempts to fill in these windows. Figure 5 provides an example of the surgical schedule of one day for one specialty and the link between the windows of opportunity and the wall. The first step is to identify the surgeries that form the windows; in this example, they are Surgery 1, 2, and 5. Step 2 is the actual creation of the windows of opportunities. This step ensures that other window surgeries (from other days) can be used to fill in today's windows. In this case, Surgery 45, 22 and 73 are the surgeries who are used to take advantage of the windows, using the optimization rules previously mentioned. Surgery 1, 2 and 5 are scheduled at a later date. Therefore, for this example, Surgeries 1, 2, 5, 45, 22 and 73 are window surgeries who create windows of opportunity; surgeries 3 and 4 form the Wall. The latter surgeries are only taken in consideration to determine the 'size' (duration) of the windows; they are not scheduled/used in the scheduling of the optimization program.

It is important to note that the windows of opportunity created by the removal of Surgeries 1, 2, and 5 are actual times of the specific surgeries. When Surgeries 45, 22 and 73 are taken in consideration to see if they fit in those windows, it is their estimated times that are

considered. Furthermore, the wall surgeries 3 and 4 do not 'move'. The only time that this is not the case is when previous surgeries take longer than anticipated. Thus, wall surgeries are shifted in order not to have two surgeries overlapping in the same OR.

Surgery 1 (2h)	Surgery 2 (1h)	Surgery 3 (1h)	Surgery 4 (1h)	Surgery 5 (1h)

Step 1. Example of the Wall

		Surgery 3 (1h)	Surgery 4 (1h)	

Step 2. Example of Windows of opportunity

Surgery 45 (2h)	Surgery 22 (1h)	Surgery 3 (1h)	Surgery 4 (1h)	Surgery 73 (1h)

Step 3. Example of using the Windows of opportunity

Figure 5: Example of the link between windows and the wall

Table 11 provides the number and percentages of wall and window surgeries as well as the relative percentage difference between them.

	Used for simulation (Wall)		Used for simulation (Windows)		
Surgical unit	Frequency	Percent	Frequency	Percent	Relative percent difference
C.T.V.	2,530	14.63	1,875	17.10	2.46
E.N.T.	2,435	14.08	1,708	15.57	1.49
General surgery	2,790	16.14	1,763	16.08	-0.06
Neurosurgery	674	3.90	595	5.43	1.53
Ophthalmology	8,861	51.25	5,026	45.83	-5.42
Total	17,290	100.00	10,967	100.00	0.00

Table 11: Surgical units analyzed – Simulation values

Multiple interviews confirmed the manner in which estimated times for the surgeries are calculated, for each surgeon: the hospital's scheduling computer program calculates the average of the past 10 surgeries for each specific surgeon (actual times of procedures). However, a surgery encompasses different procedures. The average only considers (or tags) the full duration of the surgery of the first procedure. The estimated times provided by the hospital were these times and they did not reflect the true estimated times used by the planning administrator. In the hospital, the administrator who plans and creates the schedule must be aware of all the times of all the procedures of all the surgeons. Furthermore, the planning administrator confirms and readjusts these durations with the surgeons prior the master plan is created. In order to simplify the estimated times for the centralization software, the following formula was used:

$et = at * (+/- (20\% * rand))$,

where *et* is the estimated time, *at* is the actual historical time of the surgery, *rand* is a random variable that has values between 0 and 0.9999. A surgeon can approximate quite fairly the duration of the procedure; however, there is always the possibility of positive or negative surprises when performing a surgery. It is for this reason that the 20% rule was applied. Using this formula, an estimated time for all the procedures encompassed in a surgery is based on the actual historical duration of the surgery, with a potential maximum variation of +/- 20%. These values were calculated for each surgery once and replaced the estimated surgical duration values provided by the hospital. Using these, Table 12 was created in order to provide an overview of the surgeries and some of their indicators.

Table 12 shows the estimated and actual surgical durations, the difference between them (actual – estimated), and the patient's wait time in days of the surgeries performed by the five units in the 3 year period. A further segregation of the data is also shown in order to illustrate better the figures (maximum, minimum, average (mean), and standard deviation values).

Specialty	Criteria	Estimated surgical duration (min.)	Actual surgical duration (min.)	Delta (Actual – Estimated) (min.)	Patient's wait time (days)
C.T.V	Maximum	918	815	111	1092.59
	Minimum	1	1	-108	0.35
	Mean	165.42	158.22	-7.20	166.64
	Standard deviation	105.67	100.17	19.90	229.52
E.N.T.	Maximum	877	821	104	1017.70
	Minimum	6	7	-113	1.54
	Mean	104.03	99.19	-4.84	209.06
	Standard deviation	117.47	111.69	16.37	196.03
General surgery	Maximum	907	815	117	1070.45
	Minimum	1	1	-127	0.34
	Mean	100.88	96.42	-4.46	171.14
	Standard deviation	135.25	129.62	17.86	190.40
Neurosurgery	Maximum	1132	947	113	1088.41
	Minimum	30	32	-185	1.36
	Mean	207.92	197.92	-10.00	150.80
	Standard deviation	158.78	147.39	27.00	184.66
Ophthalmology surgery	Maximum	381	359	37	1072.38
	Minimum	0	0	-48	0.34
	Mean	35.01	33.39	-1.61	244.62
	Standard deviation	34.13	32.41	5.07	256.83

Table 12: Estimated and actual surgical duration and patients' wait time by specialty

The surgeries which are of interest are the ones performed in 2013 (January 1 through December 31), shown in Table 13. Table 14 has the same format as Table 12, yet only 2013 surgeries are considered for the former.

	Total Windows		Windows used for simulation (2013)		
Surgical unit	Frequency	Percent	Frequency	Percent	Relative percent difference
C.T.V.	1,875	17.10	618	16.60	-0.50
E.N.T.	1,708	15.57	629	16.89	1.32
General surgery	1,763	16.08	635	17.05	0.98
Neurosurgery	595	5.43	203	5.45	0.03
Ophthalmology	5,026	45.83	1,639	44.01	-1.82
Total	10,967	100.00	3,724	100.00	0.00

Table 13: Surgical units analyzed – Simulation values

Specialty	Criteria	Estimated surgical duration (min.)	Actual surgical duration (min.)	Delta (Actual – Estimated) (min.)	Patient's wait time (days)
C.T.V	Maximum	918	815	78	575.59
	Minimum	2	2	-103	0.36
	Mean	171.54	164.11	-7.43	133.53
	Standard deviation	112.35	106.10	20.82	150.62
E.N.T.	Maximum	747	679	83	625.45
	Minimum	6	7	-110	1.54
	Mean	102.86	97.54	-5.32	194.87
	Standard deviation	111.13	103.42	17.16	137.84
General surgery	Maximum	814	737	117	600.57
	Minimum	1	1	-105	1.57
	Mean	98.02	94.26	-3.76	159.21
	Standard deviation	129.02	126.37	17.94	139.73
Neurosurgery	Maximum	828	719	77	530.37
	Minimum	30	32	-111	2.60
	Mean	217.61	208.12	-9.49	130.82
	Standard deviation	159.80	148.37	26.82	121.93
Ophthalmology surgery	Maximum	294	284	37	618.40
	Minimum	3	3	-34	0.40
	Mean	34.02	32.49	-1.53	193.40
	Standard deviation	32.50	30.99	5.02	155.55

Table 14: 2013 Window surgeries used for the simulation by surgical specialty

Three scenarios are analyzed in order to see if differences in the input parameters would provide better (or worse) results in comparison with the historical values. The following setup parameters are the same for all 3 scenarios.

Initial population parameters	Population size	100
Stop solution finding factors	Number of iterations	2000
	Time execution (minutes)	0.08
Crossover function parameters	Crossover probability	0.05
Mutation Function parameters	Mutation probability	0.03
	Selection probability	0.07
Minimal Request date	1 January, 2013	
All days until surgeries are finished	400	
Rolling horizon (days)	7	

Table 15: Generic parameters of the genetic algorithm

Even though the interest period is of 1 year (365 days – January 1st- December 31st 2013), the simulation length was of 400 calendar days. This was performed because the manner in which the program works. A surgery from 2013 could be scheduled in 2014; also because the scheduling period was finished, 2014 would have only empty ORs. This would skew the results. Having a 400 days period ensures that the results of the 2013 surgeries provide data that can be used in the analysis. A warm-up period was not necessary as the system and queues were already saturated.

There were 30 runs for each scenario, thus providing a sample size of 30. The different scenarios differ in the weight attributed to the following rules: "Minimize overtime", "Surgery class order", "Minimize wait time". There is a reason why each of these were selected: *Minimize overtime* – many interviewees stated that overtime should be considered due to the extra cost incurred on the nurses side; *Surgery class order* – Dr. Verter (McGill University) performed a study taking this aspect in consideration and showed that longer surgeries performed in the morning and shorter ones in the afternoon decrease the potential overtime (Interviewee 3); *Minimize wait time* – the main purpose for the research. Table 16 provides the setup distinctions between the 3 scenarios:

	Minimize overtime Weight (norm. weight)	**Surgery class order** Weight (norm. weight)	**Minimize wait time** Weight (norm. weight)
Scenario 1	0.5 (7.69%)	0.5 (7.69%)	0.5 (7.69%)
Scenario 2	0.5 (7.69%)	0.5 (7.69%)	1.0 (14.29%)
Scenario 3	1.0 (14.29%)	1.0 (14.29%)	1.0 (14.29%)

Table 16: Difference between 3 scenarios

The "Required rest time" rule was not included in the optimization; thus, the "Required estimated duration to rest (minutes)", "Required actual duration to rest (minutes)", and "Rest time value (minutes)" do not apply.

Historically, some ORs close at 3:15 PM, others at 4:00 PM, and others at 6:00 PM. Not having the data about which OR was opened until what time, the simulations obey the following rule: if an OR for a specific surgical specialty was opened during a day, the opening hours were from 7:45 to 18:00. This provides 615 minutes of open OR time. Additionally, the 18:00 closing time also provides a different analytical aspect: all the surgeons interviewed would like to have more OR time. They believe, and it is logical, that having more OR time would decrease the waiting time and reduce the waiting list. The main reason why all ORs do not close at 18:00 is

the budget: either there is no budget for extra staff to keep the ORs opened (nurses, anesthetists), or there is no budget for overtime.

Table 17 presents the difference between the 3 scenarios as well as all of the parameters used for the optimizations' objective functions weights.

Function	**Weight (Normalized weight)**		
	Scenario 1	**Scenario 2**	**Scenario 3**
Minimize overtime	0.5 (7.69%)	0.5 (7.14%)	1.0 (12.50%)
Acceptable overtime value (minutes)	15		
Minimize booted time	1.0 (15.38%)	1.0 (14.29%)	1.0 (12.50%)
Required rest time	0		
Required estimated duration to rest (minutes)	DNA		
Required actual duration to rest (minutes)	DNA		
Rest time value (minutes)	DNA		
Work in different room at the same time	1.0 (15.38%)	1.0 (14.29%)	1.0 (12.50%)
Minimize idle time	1.0 (15.38%)	1.0 (14.29%)	1.0 (12.50%)
Maximize count of surgeries	1.0 (15.38%)	1.0 (14.29%)	1.0 (12.50%)
Surgery class order	0.5 (7.69%)	0.5 (7.14%)	1.0 (12.50%)
Minimize booted count	1.0 (15.38%)	1.0 (14.29%)	1.0 (12.50%)
Minimize wait time	0.5 (7.69%)	1.0 (14.29%)	1.0 (12.50%)

Table 17: Objective functions and their weights
*DNA – Does Not Apply

Comparison between scenarios

The average simulation times of the 3 scenarios are different. Scenario 1 has the most relaxed rules, thus, it is faster than Scenario 2, and Scenario 2, for the same reason is faster than Scenario 3. The simulations were performed on a laptop having a 64-bit operating system, with 6.00GB RAM, and an Intel® Core™ i3-2370M @ 2.40GHz processor. The average times of one run are presented in Table 18.

Scenario	Average running times
Scenario 1	227.14 minutes (3.79 hours)
Scenario 2	290.22 minutes (4.84 hours)
Scenario 3	314.42 minutes (5.24 hours)

Table 18: Average simulation times

Outputs of the simulation

There are two main types of outputs of the optimizations, both provided in a CSV file format. Firstly, the 'summary results' encompass indicators which are aggregated. These are

discussed in the *Summary results* section. The main results encompass all the information for each individual surgery, presented in the *Main results* section.

Simulation summary results

There are 4 types of summary results: window surgeries booted, wall surgeries booted, idle time, and over time. Furthermore, these results take in consideration all the 400 days of the simulations. Therefore, it is assumed that the values represented are on the high end and surpassing the 2013 period of the study for idle time. The mean standard deviation was calculated by taking the square root of the average squaring of the individual SDs. This approach can be used as there are the same number of observations for each unit (30 simulations) and because the results are independent events (i.e. one run is not dependent on another run).

Table 19 provides the results to the total number of window surgeries which were planned for a specific day but did not fit in due to previous surgeries taking longer. It can be noticed that Scenario 2 provides the best results overall for the surgical units under study. Scenario 2 has the maximum weight of reducing the waiting time in comparison with the minimizing overtime and sequencing objective functions. Yet, this scenario is detrimental to some of the surgical units.

Scenario 1				
	Window booted count (simulation)			
SPECIALTY	**Max**	**Min**	**Mean**	**SD**
C.T.V.	12	0	3.9667	2.4980
E.N.T.	12	0	2.9667	2.7604
General surgery	9	0	2.5333	1.9605
Neurosurgery	1	0	0.0667	0.2537
Ophthalmology	18	1	5.2000	4.6416
Mean	10.4		2.947	2.804

Scenario 2				
	Window booted count (simulation)			
SPECIALTY	**Max**	**Min**	**Mean**	**SD**
C.T.V.	4	0	1.3000	1.2905
E.N.T.	8	0	2.0667	2.0331
General surgery	8	1	2.0667	1.7991
Neurosurgery	0	0	0.0000	0.0000
Ophthalmology	14	1	5.6000	3.6351
Mean	6.8		2.207	2.109

Scenario 3				
	Window booted count (simulation)			
SPECIALTY	**Max**	**Min**	**Mean**	**SD**
C.T.V.	5	0	1.4000	1.1919
E.N.T.	9	0	1.8000	2.1075
General surgery	11	0	2.6333	2.4842
Neurosurgery	0	0	0.0000	0.0000
Ophthalmology	15	1	5.5333	4.5008
Mean	8		2.273	2.541

Table 19: Summary of booted window surgeries by scenario

Table 20 provides the results to the total number of wall surgeries which were planned for a specific day but did not fit in due to previous surgeries taking longer. These surgeries, in the present research were not rescheduled at a further date. It can be noticed that Scenario 3 (maximum weight to all objective functions) provides the best results overall, yet it does not have the smallest standard deviation. Furthermore, these results are detrimental to two of the

surgical units under study. The booted surgeries analysis cannot be compared with the historical data as the latter data was not provided.

Scenario 1

	Wall booted count (simulation)			
SPECIALTY	**Max**	**Min**	**Mean**	**SD**
C.T.V.	3	0	0.9000	0.7120
E.N.T.	3	0	0.6000	0.8944
General surgery	4	0	1.0000	1.2034
Neurosurgery	0	0	0.0000	0.0000
Ophthalmology	7	0	3.1333	2.2854
Mean	3.4		1.1267	1.2632

Scenario 2

	Wall booted count (simulation)			
SPECIALTY	**Max**	**Min**	**Mean**	**SD**
C.T.V.	3	0	0.7333	0.8683
E.N.T.	3	0	0.3000	0.7022
General surgery	5	0	0.8667	1.3060
Neurosurgery	0	0	0.0000	0.0000
Ophthalmology	5	1	3.5333	1.4077
Mean	3.2		1.0867	0.9934

Scenario 3

	Wall booted count (simulation)			
SPECIALTY	**Max**	**Min**	**Mean**	**SD**
C.T.V.	2	0	0.7667	0.7739
E.N.T.	2	0	0.5000	0.7311
General surgery	7	0	1.1667	1.8210
Neurosurgery	0	0	0.0000	0.0000
Ophthalmology	6	1	2.7667	1.7357
Mean	3.4		1.0400	1.2216

Table 20: Summary of booted wall surgeries by scenario

Regarding overtime, results presented in Table 21, Scenario 3 provides the best overall results; yet again, this is not valid for all surgical units. The ‘Better %’ column is calculating,

using the Mean values, by how much the results of a scenario are better (positive sign) or worse (negative sign) in comparison with the base line data. The 'SD offset' column shows by how many standard deviations the historical data is off in comparison with the simulation results, where a positive sign is to the right of the simulation mean result, and a negative sign of this column is to the left of the simulation results.

The Ophthalmology surgical unit has the worse results in all 3 scenarios. This can be explained by the special characteristics of the unit and how surgeries are planned within this specific unit. In most cases, this unit is provided with 2 ORs, one of which is dedicated to cataract surgeries. This distinction was not incorporated in the model.

Scenario 1

	Historical	Simulation				Better (%)	SD offset
SPECIALTY	**Mean**	**Max**	**Min**	**Mean**	**SD**		
C.T.V.	6,219	3,338	1,968	2,366.30	271.92	61.95	14.17
E.N.T.	1,100	1,822	261	1,143.77	482.09	-3.98	-0.09
General surgery	3,580	2,544	1,265	1,931.70	329.09	46.04	5.01
Neurosurgery	3,060	2,452	1,293	1,563.77	283.71	48.90	5.27
Ophthalmology	49	198	68	107.87	30.50	-120.14	-1.93
Mean	2,801.60			1,422.68	314.98	49.22	4.38

Scenario 2

	Historical	Simulation				Better (%)	SD offset
SPECIALTY	**Mean**	**Max**	**Min**	**Mean**	**SD**		
C.T.V.	6,219	2,779	1,693	2,082.70	313.38	66.51	13.20
E.N.T.	1,100	2,043	117	960.23	464.94	12.71	0.30
General surgery	3,580	3,188	1,023	1,719.60	484.03	51.97	3.84
Neurosurgery	3,060	2,434	1,271	1,572.17	283.96	48.62	5.24
Ophthalmology	49	88	32	57.00	16.70	-16.33	-0.48
Mean	2,801.60			1,278.34	354.84	54.37	4.29

Scenario 3

	Historical	Simulation				Better (%)	SD offset
SPECIALTY	**Mean**	**Max**	**Min**	**Mean**	**SD**		
C.T.V.	6,219	2,969	1,761	2,152.73	305.15	65.38	13.33
E.N.T.	1,100	1,927	102	968.37	407.18	11.97	0.32
General surgery	3,580	2,338	1,004	1,582.90	339.97	55.78	5.87
Neurosurgery	3,060	2,404	1,266	1,583.70	327.91	48.25	4.50
Ophthalmology	49	106	32	54.97	17.26	-12.18	-0.35
Mean	2,801.60			1,268.53	310.58	54.72	4.94

Table 21: Summary overtime comparison between historical data and simulation results

Table 22 provides the results of the summary idle times and the comparison with the historical data. For idle times, Scenario 1 provides the best results overall; there are small differences between certain units in Scenario 1 and the other scenarios. However, it can be noticed that in all scenarios and for all surgical units, the simulation results are worse than the historical data. This is explained by the following 2 reasons:

1. The simulations used ORs that closed at 18:00, thus having more surgeries in a specific day;
2. The time period of the simulation considered 400 days. If the surgeries were finished in 380 days, for example, the remaining 20 days were considered as idle time.

Furthermore, as changeover between surgeries was not included in the simulations, this time is also considered idle time by the simulations (in its calculation of this time). Having all these elements, it is logical that, overall, idle time would be higher in the simulations compared with the historical data.

Scenario 1							
	Historical	Simulations				Better (%)	SD offset
SPECIALTY	Mean	Max	Min	Mean	SD		
C.T.V.	135,432	142,997	136,575	139,645.77	1,749.42	-3.11	-2.41
E.N.T.	89,724	105,459	96,514	102,015.23	2,398.47	-13.70	-5.12
General surgery	113,875	117,557	113,898	114,626.93	705.24	-0.66	-1.07
Neurosurgery	38,293	41,059	40,435	40,565.47	171.91	-5.93	-13.22
Ophthalmology	142,749	143,823	142,995	143,355.00	199.37	-0.42	-3.04
Mean	104,014.60			108,041.68	1,369.65	-3.87	-2.94

Scenario 2							
	Historical	Simulations				Better (%)	SD offset
SPECIALTY	Mean	Max	Min	Mean	SD		
C.T.V.	135,432	142,798	136,515	140,004.93	2,058.14	-3.38	-2.22
E.N.T.	89,724	151,721	122,300	138,372.40	8,282.28	-54.22	-5.87
General surgery	113,875	145,305	128,312	136,153.57	4,110.37	-19.56	-5.42
Neurosurgery	38,293	41,052	40,451	40,581.30	170.55	-5.98	-13.42
Ophthalmology	142,749	206,982	167,579	189,066.83	12,053.99	-32.45	-3.84
Mean	104,014.60			128,835.81	6,856.46	-23.86	-3.62

Scenario 3							
	Historical	Simulations				Better (%)	SD offset
SPECIALTY	Mean	Max	Min	Mean	SD		
C.T.V.	135,432	143,224	136,308	139,502.10	2,150.63	-3.01	-1.89
E.N.T.	89,724	146,051	121,602	136,307.30	6,288.07	-51.92	-7.41
General surgery	113,875	141,710	122,791	135,332.87	4,930.49	-18.84	-4.35
Neurosurgery	38,293	41,090	40,451	40,590.53	197.77	-6.00	-11.62
Ophthalmology	142,749	208,316	165,091	189,632.63	12,109.04	-32.84	-3.87
Mean	104,014.60			128,273.09	6,559.61	-23.32	-3.70

Table 22: Summary idle time comparison between historical data and simulation results

Simulation discussion

Main results

The main results encompass the optimizations outcomes for each surgical specialty and for each patient, and they take in consideration only 365 days (January 1 – December 31 2013). Tables 23 and 24 show for each surgical unit how many surgeries were taken in consideration.

Because each scenario has 30 runs, it is easy to calculate how many observations provide the population for the analysis.

The output file of each run is structured in the following manner: the rows identify each patient; the columns represent different attributes and characteristics for each patient. Before aggregating the results, all the output files were ordered by Surgical ID, as this identification mark is unique. This ensures having the same order in all the files. To ease the analysis, an MS-Excel file was created which combined the results segregated by the run for each scenario. Therefore, there were 30 columns adjacent one to another that contained all the waiting times (for example) of each patient. Having this approach, it is easy to identify all the attributes for each patient per run. Additional sheets were necessary as each one of them was dedicated to a specific surgical unit.

One of the statistics that is interesting to analyze is the number of reschedules performed. Table 23 provides these values. Even though the rescheduled surgeries represent less than 2% of the total number performed, they still count for use of resources, lost time, and additional stress for all the staff. The different scenarios provide better results for some units, but not for all of them.

			Reschedules								
			Scenario 1			Scenario 2			Scenario 3		
	Nr. of surgeries	Observations	Total (%)		Average /sim	Total (%)		Average /sim	Total (%)		Average /sim
CTV	618	18540	111	0.599%	3.70	38	0.205%	1.27	40	0.216%	1.33
ENT	629	18870	85	0.450%	2.83	54	0.286%	1.80	49	0.260%	1.63
General Surgery	635	19050	72	0.378%	2.40	61	0.320%	2.03	77	0.404%	2.57
Neurosurgery	203	6090	2	0.033%	0.07	0	0.000%	0.00	0	0.000%	0.00
Ophtalmology	1639	49170	149	0.303%	4.97	159	0.323%	5.30	155	0.315%	5.17
Total	3724	111720	419	1.763%	13.97	312	1.135%	10.40	321	1.195%	10.70

Table 23: Number of rescheduled surgeries

The number of surgeries which were performed by the optimizations on the same historical day when the surgery took place is shown in Table 24.

No change in surgery date

	Nr. of surgeries	Observations	Scenario 1			Scenario 2			Scenario 3		
			Total (%)		Average/ sim	Total (%)		Average/ sim	Total (%)		Average/ sim
CTV	618	18540	571	3.080%	19.03	520	2.805%	17.33	515	2.778%	17.17
ENT	629	18870	167	0.885%	5.57	131	0.694%	4.37	143	0.758%	4.77
General Surgery	635	19050	278	1.459%	9.27	227	1.192%	7.57	233	1.223%	7.77
Neurosurgery	203	6090	107	1.757%	3.57	120	1.970%	4.00	102	1.675%	3.40
Ophtalmology	1639	49170	416	0.846%	13.87	334	0.679%	11.13	352	0.716%	11.73
Total	3724	111720	1539	8.027%	51.30	1332	7.340%	44.40	1345	7.149%	44.83

Table 24: Number of surgeries that kept the historical date

Histograms C.T.V. 1, C.T.V. 2, C.T.V. 3 of Appendix E show, for the C.T.V. unit, the surgical estimated duration, actual duration, and the difference between the two (actual time – estimated time), respectively. These diagrams are shown as the estimated time of the surgeries were changed from those provided by the hospital. It is important to see that from the historical duration perspective, the estimated times are coherent. It can be noticed from the histograms that the estimated times and the historical ones have almost the same shape. Histogram C.T.V. 3 has a normal distribution due to the random variable of the formula used in calculating the new estimated times. The histograms depicted in these 3 tables are only for the C.T.V. unit and are used as an example. All the other units were verified in the same manner and had the same types of histograms.

Waiting times analysis

The optimizations considered the waiting times in minutes. For an easier read and understanding, these times are presented here in days.

The C.T.V. unit is provided as an example of how the calculations were performed and how the data is presented.

Histogram C.T.V. 0 (Appendix F1) shows the result of the aggregated waiting times per patient per scenario. The manner in which these values were calculated was the following: for each surgery (the file is ordered by Surgical ID, not by patient ID as a patient may have different surgeries within the same unit; if this is the case, when ordering by patient, the order may not be the same), the average of all the runs in the specific scenario were calculated. Therefore, the

historical wait time can be compared with the average simulation time of each run for each patient. The same rational applies to all the surgical units.

The method in which the results are computed in Table 25 needs explanations. The historical values of all the surgeries for all the patients are provide in the 'Historical' cap. These represent the maximum, minimum and mean (average) values, as well as the standard deviation of these values. As mentioned before, these consider 618 C.T.V. surgeries. For each scenario, the maximum and minimum values are also provided (also considering 618 entries). The Mean of the scenario results is calculated using the average of the 618 values as well; it is important to notice that even if this value is calculated using the average of the 30 simulation results, the value is the same. The 'SD of 30 runs' represents the mean standard deviation of the 30 optimization runs. The manner in which was calculated is by taking the square root of the average squaring the individual SDs of the 30 runs. The 'SD of scenario' is calculated by taking the overall standard deviation of all the mean wait times for all the patients.

The 'Better mean %' column shows by how much the simulation results for one scenario are better off (worse off) compared to the historical values. A positive sign indicates that the simulation results are better than the historical ones.

The 'Off-set' category is divided in 3 subparts and each shows by how many standard deviations a data value is off taking in consideration a mean and its standard deviation. A positive (negative) sign shows that the value of interest is to the right (left) of the mean results. SD 1 considers the mean (μ) and standard deviation of the historical values, where the value of interest is the mean (x) of the simulation. SD 2 and SD 3 consider the mean of the historical data as the value of interest (x) and the mean (μ) of the simulations; yet, for SD 2, it is the standard deviation of the 30 runs used, and for SD 3, it is the standard deviation of the scenario.

The "Better Max %" column shows the percentage by which the maximum waiting time of the scenarios are better (positive sign) or worse (negative sign) in comparison with the historical data.

The same approach is used to calculate all the results for all the surgical units.

The following subsections incorporate the simulation results and the qualitative interview data. This provides a clear picture of the simulation results that are explained using the interview data for each specific unit. Furthermore, one is able to see how the different units are organized and how they schedule their ESs.

C.T.V.

From Table 25, it can be noticed that Scenario 1 provides the best results for C.T.V.. Not only that the mean waiting time of this scenario is 21.8% better than the historical mean, but also, the 30 runs and the scenario standard deviations are smaller than the other scenarios.

C.T.V.

	Max	Min	Mean	SD						
Historical	574.6	0.4	133.5	150.6			OFF-sets (mean)			
	Max	**Min**	**Mean**	**SD of 30 runs**	**SD of scenario**	**Better mean %**	**SD 1**	**SD 2**	**SD 3**	**Better Max %**
Scenario 1	447.0	0.3	104.4	121.2	115.5	21.80%	-0.19	0.24	0.25	22.21%
Scenario 2	553.8	0.4	127.9	138.8	132.0	4.21%	-0.04	0.04	0.04	3.62%
Scenario 3	563.4	0.3	126.3	138.7	132.1	5.41%	-0.05	0.05	0.05	1.95%

Table 25: C.T.V. surgeries statistical results

The offset positioning of the historical values in all scenarios are within less ¼ of a standard deviation. The results indicate that Scenario 1 provides the best results for the patient waiting times, followed by Scenario 2 and 3. The results of the last scenarios are very close in mean and SD.

The C.T.V. surgical unit has an administrator who is building the pre-surgical schedule. Furthermore, each surgeon has a secretary; some of the secretaries are shared between physicians.

The OR time is proportionately shared between the surgeons.

There are no interactions with other surgical units. However, there are some tensions between surgeons, nurses and hospital administration characterized as ‘personality’ issues, as “some surgeons are more difficult than others” (Interviewee 6). However, the problems are under control and, as the patient is the main concern, issues between staff “do not get in the way of the patient” (Interviewee 1); “in the OR, the team is a cohesive unit” (Interviewee 6). Mainly, it is reported that there is no conflict between this unit and other units.

The patients are not shared between surgeons, even if the Chief of surgery suggested it. If patients would be shared, it would create additional problems as the surgeon builds a trust relationship with the patient during his waiting. However, urgent cases are shared: if a patient who is already on the waiting list comes to the emergency room, the surgeon on call will be the one performing the surgery.

Surgeons would like to work more, to perform more surgeries. The C.T.V. unit would like to have more specialized OR nurses, increased budget, more OR time and more ICU beds. If

these resources are provided, the unit will be able to perform more surgeries, which in turn would reduce the waiting list and waiting time of patients. One way to do this is to make the C.T.V. unit a priority in the hospital; this would ensure that the unit would have a bigger share of the pie.

It is clear that Scenario 1 also provides the best results for the maximum waiting time, having the greatest value by far, with 22.21% better, followed by Scenario 2 and 3. The only plausible reason for this is that *Minimizing waiting time* objective function weight was set at 0.5 (7.69%), which is lower in comparison with the other 2 scenarios. It can be noticed that the values of Scenarios 2 and 3 are close to the historical values.

E.N.T.

There are 629 E.N.T. surgeries considered. It can be seen from the results that all three scenarios are worse off in comparison with the historical values. This is true for the mean waiting time as well as for the maximum waiting time. Even though Scenario 1 provides much better results for the mean waiting time vis-à-vis the other scenarios, it is 17 days worse than the base line. The results of the other two scenarios are dire. Regarding the maximum waiting time, Scenario 1 is worse off by less than 1%, and Scenario 2 and 3 by a little bit more than 5%. The SD off-sets are less than 1 standard deviation. These results suggest that all three scenarios do not help the surgical planning for the E.N.T. unit, and the historical scheduling performed by this unit is much better than the centralized methods proposed.

E.N.T.

	Max	Min	Mean	SD						
Historical	625.4	1.5	194.9	137.8			OFF-sets (mean)			
	Max	**Min**	**Mean**	**SD of 30 runs**	**SD of scenario**	**Better mean %**	**SD 1**	**SD 2**	**SD 3**	**Better max %**
Scenario 1	628.5	11.9	211.8	159.8	142.3	-8.67%	0.12	-0.11	-0.12	-0.50%
Scenario 2	659.2	30.7	257.8	178.2	160.3	-32.27%	0.46	-0.35	-0.39	-5.40%
Scenario 3	661.4	27.6	256.2	178.1	160.1	-31.45%	0.44	-0.34	-0.38	-5.76%

Table 26: E.N.T. surgeries statistical results

This surgical unit also has an administrator who is responsible for the interaction with the OR booking. Secretaries are shared between different surgeons.

The interviewees reported no tensions within the unit; all the information is common knowledge between secretaries, surgeons and the administrator of the unit. There is an open communication atmosphere. There are rational arguments for everything that is done in the unit.

There are good relations between the staff of this unit and the OR administrator, and the former do not try to game the latter as "you don't live in the moment, you live long period of time" (Interviewee 7). Furthermore, there are no interactions between this unit and other surgical units. The unit is concerned with itself and what it can do for its patients as there is no time to look into other units. The last two points are valid and apply to all the remaining surgical units under study.

The interviewed surgeons make the distinction between discontent and disagreements. The little disagreements that Interviewee 8 has noticed between surgeons, nurses and anesthetists were resolved in the open and in a timely manner. The surgeon is not *God* in the OR; the nurses and anesthetists are also part of the team and surgery is a team effort.

The following aspect applies only in this unit: there are two surgeons who share the patients depending on their OR availabilities; this is done with the rationale that the first priority is the patient. Otherwise, patients are not shared between surgeons.

OR time scheduling is based on seniority, which means it is a question of the length of the surgeon's waiting list. The scheduling is based on the patient needs and comorbidities, thus the patients are triaged. If other surgical units have more OR time, there is a valid reason for it. If surgeons lose their OR time due to an emergency, even if they are discontent, they understand the situation. The situation is fair and surgeons get along, even though surgeons fight for their own patients.

More OR time and better access to resources would be needed in order to reduce the waiting list. However, the unit does the best it can and "you use the resources available to you" (Interviewee 7).

There are three possible reasons why the historical data is different in comparison with any scenario. First of all, there a 'high efficiency day' where there is no teaching present for any of the professionals who perform the surgery. Even though this method of scheduling is resource intensive, it is able to have a high output of surgeries during the specific day. However, 'high efficiency day' is only performed by one surgeon. Another reason why the historical values might be better than any of the centralized scenarios is that two surgeons share some of the patients. E.N.T. is the only unit which has these two different approaches to scheduling and performing their surgeries. Moreover, it is also noticed that the OR allocation is based on the length of the surgeons' patient list.

General surgery

There are 635 General surgeries that are considered. Scenario 1 provides the best results for both the mean and maximum waiting time, with 6.03% and 12.09% respectively better than the base line. Scenario 2 and 3 are worse off, having the former taking the last place. Scenario 1 is better by almost 10 days mean waiting time and 72 days better regarding the maximum waiting time in comparison with the base line. The results of the other two scenarios are dire regarding their mean waiting time, yet still comparable for their maximum wait time. The SD off-sets are well within the 1 standard deviation. Therefore, only Scenario 1 provides better overall results when compared with the base line.

General surgery

	Max	Min	Mean	SD						
Historical	600.6	1.6	159.2	139.7			OFF-sets (mean)			
	Max	Min	Mean	SD of 30 runs	SD of scenario	Better mean %	SD 1	SD 2	SD 3	Better max %
Scenario 1	528.0	0.6	149.6	137.2	125.5	6.03%	-0.07	0.07	0.08	12.09%
Scenario 2	612.5	8.8	194.6	160.6	145.2	-22.24%	0.25	-0.22	-0.24	-1.98%
Scenario 3	603.7	12.5	190.9	160.2	143.9	-19.91%	0.23	-0.20	-0.22	-0.52%

Table 27: General surgeries statistical results

In comparison with the previous two surgical units, this unit does not have a dedicated administrator; it is the responsibility of the Chief of the unit to administer the scheduling. Building the OR schedule, the Chief takes many aspects in consideration, such as the surgeons' preferences and their clinical hours. Qgenda computer program is used for this task.

The OR scheduling allocation is not based on seniority; it is proportionate to the number of surgeons within the unit. OR allocation is also dependent on the surgeon's academic contribution: if a surgeon has more academic contributions, more OR time is given to that surgeon. Within certain groups, the OR time allocation is equal. Most surgeons do not push to get more OR time as they know that it will not be given to them, even though the patients' anxiety is transferred to the surgeons.

Generally, the surgeons have a full OR day. If it is a shared OR, surgeons try to be considerate, not to exceed their allocated OR time which would result in entering another surgeon's time (Interviewee 12).

Scheduling of patients is based on the diagnostic as well as the benchmarks imposed by the government. If however the waiting list becomes long, there is no manner in which

accommodations can be provided in the OR. In order to address this, some of the surgeons of this unit redirect patients.

There is “no overt hostility” (Interviewee 4) in the unit and a collegial atmosphere is present; surgeons are also supporting and accepting of their colleagues. However, it was mentioned that there is a certain ‘semi-charged’ atmosphere between surgeons and nurses, but no one will confirm it (or deny it). The only disagreements between surgeons and OR time allocation are in the emergency-flex time. These conflicts are resolved by the priority of the patient, which it is the anesthetists who are supposed to resolve it. However, the anesthetists encourage surgeons to talk between them.

Furthermore, there are certain attitudes present as the nurses and/or anesthetists ‘pressure’ the surgeon to speed-up the surgery. Residents are slower, but they do a good job. Yet, this is a two way street, as it is a teaching hospital and teaching in the OR takes more time for the surgery. Due to these elements, at times, it is not a cordial environment. The attitude is presented in the form of how comments are made. People have different opinions of how people are performing their jobs. As in any big organization, frictions due to different personalities are bound to arise (Interviewee 4).

Finding more OR time is not dependent on the surgeon. Everyone gets frustrated when cancelations happen; they occur because there are no ICU beds, after the surgery, for the patients. More nurses and anesthetists are required to perform more surgeries. The main impediment for performing more surgeries is the budget. Emergency-flex time is given also to cancelled/booted patients and all surgeons believe that their patient is more important than anyone else’s, resulting in previously mentioned tensions.

The schedule changes due to medical reasons. If a patient comes in and is acute, there is the possibility that a surgeon can swap their OR time with another surgeon. The time swapping is used by all the surgical units where this research is performed. It is the responsibility of the surgeon to manage his own list, meaning that it is the surgeon who decides when a patient receives the surgery. However, not all surgeons update their waiting lists. Patients could have had their surgery in another hospital, patients’ acuity might have changed, or, worse case, some died.

There is no shortage of surgeons. The absence of more nurses and lack of other resources are the major constraint in performing more surgeries.

It is clear the Scenario 1 provides the best values. One of the probable reasons is that the Minimization of waiting time objective function does not have its maximum weigh.

Ophthalmologic surgery

There are 1,639 ophthalmology surgeries which provide the analysis results. Scenario 1 has the best results for the mean and maximum waiting time with 22.29% and 28.06% respectively. Scenario 2 and 3 are worse off for their mean waiting time (5.07% and 4.86%), yet better for in their maximum wait time (1.83% and 7.2%). There is a difference of 43 days in the mean waiting time and 174 days in the maximum waiting days between Scenario 1 and the base line values. For Scenario 2 and 3 the differences in the results are not prone, save for the maximum waiting time of Scenario 3 which has a difference of 45 days. Once again, the SD off-sets are less than 1 standard deviation. Therefore, Scenario 1 has the best overall results, followed by Scenario 3 and 2, respectively.

Ophthalmology

	Max	Min	Mean	SD						
Historical	618.4	0.4	193.4	155.6			OFF-sets (mean)			
	Max	Min	Mean	SD of 30 runs	SD of scenario	Better mean %	SD 1	SD 2	SD 3	Better max %
Scenario 1	444.9	0.3	150.3	126.3	115.5	22.29%	-0.28	0.34	0.37	28.06%
Scenario 2	607.1	12.2	203.2	149.1	122.5	-5.07%	0.06	-0.07	-0.08	1.83%
Scenario 3	573.9	12.5	202.8	149.3	123.0	-4.86%	0.06	-0.06	-0.08	7.20%

Table 28: Ophthalmological surgeries statistical results

There is no information of this unit having an administrator. However, it is presumed that the surgeons have secretaries.

Cataract surgeries are scheduled on a first come first served basis. However, comorbidities ensure that the patient is scheduled faster. This specific aspect was not incorporated in the simulation modeling.

The patients are not shared between the surgeons, as “it is a doctor-patient relationship and not surgical task oriented efficiency” (Interviewee 10). “The patient’s relationship is with the doctor, not with the institution that will get … any surgery done” (Interviewee 10).

It is a pleasant working environment and there are no tensions mentioned between surgical units. However, there are sometimes differences in opinions and attitudes between the nursing staff and surgeons.

A couple of years ago, cataracts became a priority for the government and as such the latter invested a lot of funds in order to reduce the waiting lists because if vision is not resolved, the patient might have other problems (they may fall and have fractures, etc.). The number of cataract procedures is tied to the individual surgeon.

Ophthalmology has a different approach in its scheduling the surgeries: there is one surgeon, but two ORs and two surgical teams. This aspect was also not incorporated in the modeling. This different approach ensures a higher efficiency for the surgeon as he does not waste time between surgeries; the patient is already prepped and awaiting in the second room. This method of scheduling and performing surgeries is only applied by one surgeon out of 11 surgeons within this unit. As it will be mentioned latter, this method of scheduling and performing surgeries can only be accomplished only for specific types of surgeries.

There is a lot of downtime in order to setup the patient for surgery. There is also a lack of nurses and because of changeover, retirements, and leaves, the OR is less efficient. The same type of procedure for the entire day with the same team is the most efficient, and subspecialized teams would increase efficiency. Nurses from different services that are not experts in ophthalmology would reduce the efficiency of the room.

It must be noted that ophthalmology lacks the need for the classical hospital resources, such as beds, pre-operative testing, radiology. For these reasons, this unit can be considered exceptional unit in comparison with other surgical units in the entire hospital.

As Scenario 1 has the best (22.29% better than the next best scenario) average values, it is also believed that having a low *Minimum wait time* weight is the major contributor for this good value. Furthermore, there are certain attributes of the simulation modeling that were not considered: first come first service for cataracts, 1 surgeon-2 ORs-2 surgical teams, and absence of classical hospital resources. The coupling of these two aspects might provide the much better results for Scenario 1, and very close results between Scenarios 2 and 3 with the base line values.

Neurosurgery

For the 203 Neurosurgeries considered, only Scenario 1 provides better results, yet these are negligible for the mean wait time (0.84% better). The maximum wait time has decreased by 8.35% compared with the base line. Scenarios 2 and 3 are worse off for the mean percentage (3.21% and 1.91% respectively) and only 0.21% and 2.04% for the maximum wait time. Even

though these results do not differ a lot from the historical values, they are still worse. Therefore, it can concluded that centralization of scheduling has a very minor benefit for the mean wait time, but better values for the maximum wait time for patients' surgeries using Scenario 1. The SD off-sets are very negligible.

Neuro-surgery

	Max	Min	Mean	SD			OFF-sets (mean)			
Historical	530.4	2.6	130.8	121.9						
	Max	**Min**	**Mean**	**SD of 30 runs**	**SD of scenario**	**Better mean %**	**SD 1**	**SD 2**	**SD 3**	**Better max %**
Scenario 1	486.1	0.8	129.7	123.0	109.4	0.84%	-0.01	0.01	0.01	8.35%
Scenario 2	531.5	0.8	135.0	130.5	119.5	-3.21%	0.03	-0.03	-0.04	-0.21%
Scenario 3	541.2	0.4	133.3	129.4	118.9	-1.91%	0.02	-0.02	-0.02	-2.04%

Table 29: Neuro-surgery statistical results

Neurosurgery also does not have an administrator dedicated to the unit. However, each of the two surgeons of the unit has his own secretaries who are additionally responsible for the patient's pre-operative testing required.

Seniority plays an important part in the allocation of the OR times. The reason for this is that new surgeons need to build their patient list; thus, the surgeon who has a larger patient-waiting list would receive more OR time. The emergency-flex time that is allocated each week is utilized. Furthermore, this unit has a low volume of patients and it requires little scheduling. Moreover, shorter surgeries would ensure that more surgeries are performed in the OR.

There are no disagreements stated in the interview between the two surgeons of the unit. Furthermore, there are no tensions between the nursing staff and the surgeons that were mentioned. The OR staff is a cohesive unit and everyone supports each other.

It is the surgeon's responsibility that a patient should receive surgery in a timely manner and patients are not shared. In order to manage properly the waiting list, surgeons limit their practice, meaning they specialize; the patients not part of that specialty/category, are referred to other surgeons. Surgeons who do not refer, usually have long waiting lists. If the waiting lists are not properly managed, it "creates a monster" (Interviewee 11).

Interviewee 11 mentions that having more patients, bringing more patients in the hospital, the hospital would need more resource because then 'you are committed'. This is part of the previously mentioned monster and "it is like vicious circle".

The reason why the difference between Scenario 1 and the base line values (and actually between all the scenarios) is small might be that this unit is highly specialized and that there are

only two surgeons in the unit. The fact that the interviewee stresses the importance of proper management of the waiting list, making sure that the waiting list does not grow considerably through the process of referrals, and taking in consideration that this unit has the lowest average historical waiting time (having also a very close standard deviation to the average value) might explain the close results between all the scenarios analyzed.

Patient waiting time

In order to see the results in an aggregated manner, Tables 30 and 31 show the mean and maximum waiting times for the different units using the different scenarios. Table 30 provides the waiting days; Table 31 provides the ordering of the scenarios for a specific measure while a smaller number is better than a larger number.

		Historical	Scenario 1	Scenario 2	Scenario 3
C.T.V.	Mean	133.5	104.4	127.9	126.3
	Max	574.6	447.0	553.8	563.4
E.N.T.	Mean	194.9	211.8	257.8	256.2
	Max	625.4	628.5	659.2	661.4
General surgery	Mean	159.2	149.6	194.6	190.9
	Max	600.6	528.0	612.5	603.7
Neurosurgery	Mean	130.8	129.7	135.0	133.3
	Max	530.4	486.1	531.5	541.2
Ophtalmology	Mean	193.4	150.3	203.2	202.8
	Max	618.4	444.9	607.1	573.9

Table 30: Aggregated waiting times (days)

		Historical	Scenario 1	Scenario 2	Scenario 3
C.T.V.	Mean	4	1	3	2
	Max	4	1	2	3
E.N.T.	Mean	1	2	4	3
	Max	1	2	3	4
General surgery	Mean	2	1	4	3
	Max	2	1	4	3
Neurosurgery	Mean	2	1	4	3
	Max	2	1	3	4
Ophtalmology	Mean	2	1	4	3
	Max	4	1	3	2

Table 31: Waiting times ranking

	the best	1st place
		2nd place
		3rd place
	the worst	4th place

Legend

It is clear that the Scenario 1 provides the best results regarding average and maximum waiting time for surgeries within 4 of the 5 units under study. The exception is the E.N.T. unit where the best results are provided by the historical values. Furthermore, Scenario 2 provides the worse results overall.

It must be mentioned that there are certain situations in which one scenario is better (or worse) by a very little margin. A good example is E.N.T. Historical and Scenario 1 for their maximum waiting time; the difference between these is only 3 days. Another example is General surgery average waiting time in Scenarios 2 and 3; the difference is only 4 days.

Windows booted count (simulations)

As the data provided by the hospital did not include this approach, there is no historical data to be considered for surgeries which are of interest.

Tables 32 and 33 show the number of window surgeries that were scheduled in a day but had to be rescheduled in another day because the previous surgeries within a day took longer than expected.

It is clear that Scenario 2 offers the best results, meaning that it has the lowest number of booted surgeries. Neurosurgery has the same amount (0.0) of booted surgeries in Scenarios 2 and 3. For this reason, these scenarios are considered to have the same ranking.

There are some important discrepancies between some scenarios (for C.T.V. Scenario 1 and 2 maximum amount – difference of 8 surgeries), yet there are also some minor differences in other units both for the average and maximum number of surgeries which were booted.

		Scenario 1	Scenario 2	Scenario 3
C.T.V.	Mean	4.0	1.3	1.4
	Max	12	4	5
E.N.T.	Mean	3.0	2.1	1.8
	Max	12	8	9
General surgery	Mean	2.5	2.1	2.6
	Max	9	8	11
Neurosurgery	Mean	0.1	0.0	0.0
	Max	1	0	0
Ophthalmology	Mean	5.2	5.6	5.5
	Max	18	14	15

Table 32: Window surgeries booted count

		Scenario 1	Scenario 2	Scenario 3
C.T.V.	Mean	3	1	2
	Max	3	1	2
E.N.T.	Mean	3	2	1
	Max	3	1	2
General surgery	Mean	2	1	3
	Max	2	1	3
Neurosurgery	Mean	3	1	1
	Max	3	1	1
Ophthalmology	Mean	1	3	2
	Max	3	1	2

Table 33: Booted window surgeries ranking

	the best	1st place
		2nd place
	the worst	3rd place

Legend

OR overtime

The historical value of OR overtime is only considered as the average overtime. It must be reminded that the simulations in all 3 scenarios have a longer duration in the ORs. Therefore, the results for this indicator are slightly misleading.

The results are mixed. For some surgical units, a scenario is better (4 overall points for Scenario 2 with C.T.V. as the unit which is best suited for this scenario), yet for other units a different scenario is better (3 overall points for Scenario 3 with General surgery as the unit which would benefit the most). Quite interestingly, for Ophthalmological surgeries, neither scenario is better in comparison with the historical values.

		Historical	Scenario 1	Scenario 2	Scenario 3
C.T.V.	Mean	6,219.0	2,366.3	2,082.7	2,152.7
	Max		3,338.0	2,779.0	2,969.0
E.N.T.	Mean	1,100.0	1,143.8	960.2	968.4
	Max		1,822.0	2,043.0	1,927.0
General surgery	Mean	3,580.0	1,931.7	1,719.6	1,582.9
	Max		2,544.0	3,188.0	2,338.0
Neurosurgery	Mean	3,060.0	1,563.8	1,572.2	1,583.7
	Max		2,452.0	2,434.0	2,404.0
Ophthalmology	Mean	49.0	107.9	57.0	55.0
	Max		198.0	88.0	106.0

Table 34: Aggregated overtimes (minutes)

		Historical	Scenario 1	Scenario 2	Scenario 3
C.T.V.	Mean	4	3	1	2
	Max		3	1	2
E.N.T.	Mean	3	4	1	2
	Max		1	3	2
General surgery	Mean	4	3	2	1
	Max		2	3	1
Neurosurgery	Mean	4	1	2	3
	Max		3	2	1
Ophthalmology	Mean	1	4	3	2
	Max		3	1	2

Table 35: Overtimes ranking

	the best	1st place
		2nd place
		3rd place
	the worst	4th place

Legend

Once again, the differences between some of the scenarios is marginal (neurosurgery is a good example), however some of the differences are more significant (C.T.V. maximum values).

Idle time

The historical value of OR idle time is only considered as the average idle time. It must be reminded that the simulations in all 3 scenarios have a longer duration in the ORs.

It is clear that the base line provides the best results for the average idle time and Scenario 1 for the maximum. It should be mentioned that if the OR time is increased during a day, there is a strong possibility that the idle time increases as well. It can also be noticed that the differences between some of the scenarios for certain units (e.g. C.T.V. mean) are very small.

		Historical	Scenario 1	Scenario 2	Scenario 3
C.T.V.	Mean	135,432	139,646	140,005	139,502
	Max		142,997	142,798	143,224
E.N.T.	Mean	89,724	102,015	138,372	136,307
	Max		105,459	151,721	146,051
General surgery	Mean	113,875	114,627	136,154	135,333
	Max		117,557	145,305	141,710
Neurosurgery	Mean	38,293	40,565	40,581	40,591
	Max		41,059	41,052	41,090
Ophthalmology	Mean	142,749	143,355	189,067	189,633
	Max		143,823	206,982	208,316

Table 36: Aggregated idle time (minutes)

		Historical	Scenario 1	Scenario 2	Scenario 3
C.T.V.	Mean	1	3	4	2
	Max		2	1	3
E.N.T.	Mean	1	2	4	3
	Max		1	3	2
General surgery	Mean	1	2	4	3
	Max		1	3	2
Neurosurgery	Mean	1	2	3	4
	Max		2	1	3
Ophthalmology	Mean	1	2	3	4
	Max		1	2	3

Table 37: Idle times ranking

	the best	1st place
		2nd place
		3rd place
	the worst	4th place

Legend

It could be argued that the results for this indicator are misleading as in the case of overtime. However, the baseline values are very close to most of the values of the scenarios which provides the next best results. For this reason, these estimates are not misleading.

Having the same argument, it can be concluded that there are two reasons why the historical values are ranking low in the overtime indicator are: 1. increased OR time; 2. hard schedule cutoff. The second point refers to the fact that even if it planned from the beginning, surgeries cannot surpass the closing time; furthermore, there is a 15 minutes buffer (which is considered in the overtime calculations). In reality, the surgical schedule is re-assessed during the day. This means that nurses and anesthetists re-evaluate the schedule during the day. Errors in the new estimates can always be present. In the simulation scenarios, this procedure is not performed.

COMING TOGETHER

From these results, it can be concluded that while some scenarios are better than others, the difference between a better or worse one is minimal in certain cases. This is valid for all the surgical units and for the average and maximum values considered. Therefore, the management of the hospital should also consider the differences between the scenarios in order to conclude if a scenario is really considered better in comparison with another. The best approach would be to consider percentage brackets (which would be adequate as it normalizes the values, thus being able to compare *likes* with *likes*): if the percentage difference is under the threshold bracket, then the difference is not considered as *minimal*. The percentage thresholds could only be determined by the hospitals management.

One aspect which needs to be considered is the fact that each optimizing formula is dependent, which is easier to notice with the normalized weights, on all the other optimization objectives. This assessment is perceived by observing the outcome results of the three scenarios. Responding to the needs of one type of stakeholder has direct implications on other stakeholders. Therefore, it is not only important for management to consider only what it needs to be optimized (for example minimizing the wait time for patients), but also consider the following question: if factor X is the most important one to be optimized, what other factors and optimizations are considered for this result? This aspect also emphasizes a crucial element regarding optimization and simulation problems: they are a decision-support tool, not a decision-making one.

		Historical	Scenario 1	Scenario 2	Scenario 3
C.T.V.	Mean	4	3	2	1
	Max	4	2	1	3
E.N.T.	Mean	1	4	4	2
	Max	1	2	4	4
General surgery	Mean	2	1	4	3
	Max	2	1	4	3
Neurosurgery	Mean	2	1	3	4
	Max	2	4	1	4
Ophtalmology	Mean	1	2	4	3
	Max	4	2	1	3
		2.30	2.20	2.80	3.00

Table 38: Scenario ranking

	the best	1st place
		2nd place
		3rd place
	the worst	4th place

Legend

Aggregating all the scenarios' ranking, including the historical values, provides the basis of Table 38. The manner in which the values are calculated is the average ranking for each scenario (a lower value represents a better scenario). It must be noted that for Windows booted count indicator, the OR overtime and Idle time – Maximum values were not included in the calculations. Table 38 provides the ranking of the average values for each scenario. These represent the overall ranking, at the hospital level. There are no weights attributed to either

indicator; the hospital's management might find it appropriate to weight the different indicators based on the importance that the former would consider, based on the different pressures that certain stakeholders might have.

Some of the aggregated results for certain units are very different in value. Overall, Scenario 1 ranks the best between all the scenarios, followed by the base line, Scenario 2 and 3, respectively. Yet, the difference between this scenario and the historical values is minimal. Surprisingly, Scenario 3 provides the worse values, even though all the weights of the optimization rules were at their maximum. A plausible explanation is that it is not only the weights of a particular rule that is important, but its relative strength to the other rules.

Therefore, it is strongly argued that the decentralization or centralization within certain surgical units is extremely dependent on the instruments which the hospital's management has at its disposal and what it considers as important for the hospital as a whole.

DISCUSSION

The *Discussion* section presents various perspectives and interpretations regarding the theoretical, qualitative and quantitative inferences of the present research. The qualitative interview data provides the prism through which the different theoretical aspects are summarized. Furthermore, different elements of contingency theory (including resources, management, and different stakeholder's perspectives) are also incorporated, providing thus the special traits present in a hospital setting. Specific attention is paid to the 5 units that were studied; these are also coupled with quantitative outputs of the computer simulations. This section also provides different interpretation and tables which show certain variables that would work better in a centralized or decentralized structure, consequently providing the general ideas of which system has a superior configuration.

The models presented by Bunderson et al. (2000) are very present in the hospital under study. The bureaucratic model can be felt though the entire hospital, in all the units visited. The institution is built in such a manner that it fosters coordination between units, it aims to be as efficient as possible within some important constraints, such as providing cancer patients their surgeries within 28 days and within a very tight budget. The budget aspects also lead to the understanding of how the hospital falls under the umbrella of the market enterprise model. There

is a fierce competition between hospitals regarding patients, as it is the number of patients serviced by the hospital that determines the budgetary allocations provide by the government.

As the hospital staff is highly trained with a high degree of technical competence, it is easy to see why this institution can also be explained by the professional group model. The community service model, explained by Bunderson et al. (2000), caters to the needs of the population as the hospital is intended to apply its professional expertise to society at large. Therefore, it can be argued that the budget and population are the external driving forces of the hospital; the internal forces that align these interests with the interests of the internal stakeholders are the bureaucratic processes that consider division of labor and specialties, including as well the differences in authorities, and the coordination mechanisms that make the hospital work in an efficient manner.

It can be stipulated that the creation of the ES schedule is a uniform event because it is a repetitive task and it is performed by a highly skilled employee. However, the element that characterizes the best scheduling formation as a uniform event is the fact that the environment is constantly changing: every day, there are new patients that have very specific needs, the resources available are in constant flux, and the staff performing the surgeries falls under different categories that need to be coordinated (nurses, administrators, surgeons, anesthetists, respiratory technicians, etc.).

All these contribute to the difficulties to administer any hospital. However, the task is exponentially more challenging when the hospital is a general hospital. Wilson (1963, p. 69) describes very well the different facets of this institution:

> The large general hospital is the prototype of the multipurpose organization; it is a hotel and a school, a laboratory and a stage for treatment. All these purposes, their attendant values and specialized personnel, must be somehow articulated into a going concern. Co-ordination of specialized activity into a whole that makes organizational sense is the huge and delicate task of the administrator, a task that is never completed to anyone's entire satisfaction.

One of the elements that are present in any type of hospital is the different hierarchies. As different staff is trained for a specific specialty (nurses, surgeons, administrators), all can be placed in different hierarchies. Within each domain of expertise, different actors compete for authority and for resources. Yet, as Litwak (1961) maintains that providing each stakeholder the decision authority within his own tasks, it decreases the hierarchical structure and transforms it

in a more 'collegial' relationship between staff. At this point, it is the administrator's duty to coordinate between all the units and the staff of the units, while taking in consideration all the different demands and requests that the actors have.

The literature suggests that there are tensions and anxieties between the surgeons and nurses. However, in the hospital under study this aspect was not present. There were no vivid conflicts reported between the members of the different staff groups of surgeons, nurses or administrators. The only tensions between surgical units are grounded on the desire of each unit to have more OR time; however, the allocation of the OR time to units is based on elements exterior to the units themselves. The little disagreements between surgeons and nurses are minimal and were characterized by several interviewees as "different personalities" in a big organization.

Even though the absence of tensions and conflicts is not characteristic of most hospitals, Litwak (1961) showed in his study that the medical and administrative systems can coexist together without any clashes. It seems that the staff of the hospital presented in this research acknowledges and conforms to the pre-allocation distribution of authority. As in Litwak's (1961) analysis, there is minimal friction between the nurses, surgeons and administrators as they are aware that certain decision are to be made having local discretion, while others decisions are made in a centralized manner, especially when it comes to the coordination of all the elements that affect the creation of the surgical schedule performed by a specialist.

The literature also argues that both nurses and physicians have different perspectives when it comes to patients. However, one element is constant in the interviews performed: the importance of the patient, and the desire to provide the best care possible to the patient. It is for this reason that 'negotiations' are performed between the stakeholders. As Interviewee 8 mentions, the nurses and anesthetists are part of the OR team, and the patients' conditions and procedures of the surgery are discussed prior the surgery as well after the surgery is performed. This aspect also shows that there is a collegial and cordial atmosphere and communication is done in an open manner. This is also valid between units and different staff of the units.

Even if Martin (1980) distinguished between the administrative and clinical hierarchies, in the present hospital, these two elements do not contradict each other: in fact, they support each other, having as the common denominator the interests of the patient. To reiterate, all the staff of the units interviewed place the latter as the top priority within the unit.

As such, the bureaucratic segregation of skills does not impede the professional authority which the different professions have within this hospital. This results in the following conclusion: the three different staff categories that were studied realize their roles and duties, and the authority realms rarely overlap. It is for this reason that it could be argued that this hospital behaves in the same manner as the one in Litwak's (1961) study.

Regarding decentralization and centralization structural setup, it can be seen that certain decisions are made in a decentralized manner. These include the surgeons' decision to manage their own waiting lists, to decide when a patient will undergo surgery, shifting more acute patients by making sure that they receive their surgery faster. However, the surgeons need to plan their surgeries based on the OR time allocated to them. The OR distribution is accomplished through a centralized manner as the OR time is spread by the Chief of surgery to the individual surgical units, and the Chief of the unit re-distributes it to the surgeons within that unit, based on some criteria. Furthermore, the coordination of all the units and the creation of the Master Surgical Schedule are also done through a centralized method. Only a centralized system can provide the best coordination mechanism, as argued by Interviewee 5. However, most interviewees believe that the full centralization of the entire scheduling system might not be a very effective structure. Therefore, certain decisions still need to be made at the unit level, thus maintaining a partly decentralized organization.

As mentioned before, the hospital needs to adjust itself to different demands, may those be internal or external to the organization, as per the four models of Bunderson et al. (2000). In order to do so, contingency theory is able to explain very well the manner in which the organization is searching to have the best fit to its environment and to provide the best services to its constituents. Figure 2 explains very well the balance between the environment, the resources, which most of the time are provided by the environment and management in its quest to utilize in the best way those resources. One of the biggest constrains of the hospital is the budget, its greatest resource. Having a bigger budget, the hospital's management could increase the number of hours of the ORs. This would result in performing more surgeries, reducing the waiting list and waiting time of patients. The argument made by Luthans and Stewart (1977) that the goals of the organization are set by the different stakeholders takes in consideration not only the accomplishment of those goals within the different constrains, but also demands a very high coordination between the four models of Bunderson et al. (2000).

It must be mentioned, as it was done before, the performance difference between certain scenarios in the quantitative simulations of this study is very small; this is not to overshadow the grater differences in the values of the scenarios under consideration. However, if there is a big or a small difference between two scheduling methods, the one which prevails is the one that ranks higher; it does not matter if the outcome is 1 day or 50 days, the scheduling procedure which has the better value is considered as 'the best'. It is for this reason that the threshold brackets are recommended. Furthermore, for the small differences between the historical values and a centralized scenario, it must be reiterated that the OR time during a day was increased in the simulation from the original historical counterpart. This may be one of the reason why there is a better (or worse) scheduling system when the decentralized one is considered in contrast.

The main indicator which this research aims to compare between surgical units and between the centralization scenarios and the decentralization method of surgical planning is the time that patients wait for their surgery. It must be noted that centralization Scenario 1 provides the best results for 4 out of the 5 units under study with reference to patients' waiting time. This is valid with reference to the other two centralized scenarios as well as to the decentralization scheduling approach. The surgical unit where the historical values (decentralization) are better than any centralization scenario is E.N.T. This can be explained by three different aspects through which this unit schedules its surgeries: high efficiency days (as no training is performed during surgery and it is a resource intensive day), shared patients between two surgeons (improving the sequencing of patients), and OR allocation based on the waiting list.

It can be noticed that the Neurosurgery unit has the smallest difference between the base line and Scenario 1, 1 day. It is interesting to observe that of all the surgical units, this one has the lowest number of surgeries performed during the 1 year period. Furthermore, the average time of the surgeries performed by this unit is a lot longer than any of the other units. As it was mentioned by one of the interviewees, centralization would not be appropriate for this unit as there is little variability between the surgeries, the waiting list is properly managed by referring patients to different surgeons, and the fact that this unit has the lowest number of surgeons: 2. Having a few surgeons in a unit simplifies the decentralized coordination; this is based on the idea that surgeons share the same values, focused on patient priority, and have good knowledge about each other's constraints.

The Ophthalmology surgical unit has the most surgeries analyzed, and this unit has the greatest difference between centralization Scenario 1 and the historical values: 43 days. Therefore, it can be argued that Scenario 1 provides the best average results for patient waiting. The same can be said for the maximum time waited by the patients, with a difference of 173 days (as the historical values are the worst in comparison with all the other scenarios analyzed). It is of note that this unit has a first come – first served scheduling for cataract surgeries. However, all other types of surgeries are triaged based on the diagnostic and performed in due time. All other units also use the diatonic of the patient in order to determine the surgery date. The fact that this unit has a 2 ORs-2 teams-1 surgeon scheduling procedure for specific surgeries should not greatly affect the mean wait times as this method of scheduling is only used by one surgeon. It is also surprising that this unit has the greatest difference in average wait times as this is the only surgical unit of the hospital which does not utilizes extra hospital resources, such as anesthetists, ICU beds, and others. A possible reason explaining these results is the fact that the scheduling algorithms of the simulations did not take in consideration two important aspects regarding the scheduling procedures of this unit: there are only two rooms dedicated to ophthalmology, of which one is dedicated to cataracts; there is a first-come-first served scheduling procedure. These factors introduce constraints and routines into the scheduling procedures and they were not included in the simulation modeling, which could be the reason for this great difference between the hypothetical scenarios and the historical values.

There are only 10 days difference between the centralized Scenario 1 and the historical average data for the General surgery unit. This difference is smaller in comparison with any other scenarios analyzed. One important element of this unit is that it has the greatest number of surgeons in comparison with all the other units analyzed. Furthermore, it was the only unit that mentioned the use of the Qgenda scheduling program which takes in consideration the OR times, the surgeon's preferences, and the surgeon's schedule. The latter features were not incorporated in the simulation modeling as this research primary focus in on OR disposability and sequencing of patients. However, these factors even if they are important at the hospital and unit level, make salient notice assertions that the decentralization of the schedule helps this specific unit.

As mentioned before, the C.T.V. unit was considered as a conglomerate of 3 units: cardio-surgery; vascular-surgery; and, thoracic-surgery. Even though two of these units were merged together by the hospital, for various reasons, it provides an almost 30 days difference

between the centralized Scenario 1 and the historical base line. Not considering any other scheduling procedure which is different between all the units, and that this unit has many surgeons, with surgeries which vary in actual time and diagnostics, it is safe to assume that centralization would provide improvements on the average waiting time of patients.

It is important to note that any canceled surgeries are not considered in the historical data, as this information was not provided by the hospital. There is a high probability that patients were scheduled for their surgery but were canceled, thus being rescheduled and receiving their surgery at a later date. The cancelations, which are not dependent on a specific unit, are not dependent on a unit's prerogative: emergencies coming in the hospital shift all subsequent surgeries; lack of resources after a surgery is scheduled (ICU beds, absent nursing team, absent anesthetists).

All the staff that was interviewed for this study do not recommend the centralization of all aspects related to elective surgeries. Segregating stakeholders by their role, Table 39 is presented. Regarding the schedules of the different staff, some aspects need to be centralized while other decentralized.

Category	**Centralization**	**Decentralization**
Patients	X	
Staff schedule (surgeons, nurses, OR staff)	X	X
Booking - patients (high level)	X	

Table 39: Centralization vs. Decentralization – Stakeholders

Table 40 indicates if a centralized or decentralized system would respond better (provides better results) regarding certain indicators that were used in the simulation of this study. It can be notice that most of them would perform better in a centralized configuration.

Category	**Centralization**	**Decentralization**
Many patients	X	
Short surgical duration	X	
OR overtime	X	
OR idle time		X
High number of surgeons within a unit	X	
High number of surgeries for a unit	X	
Highly complex surgeries		X
Different variety of surgeries performed within a unit	X	
Cancelled surgeries	X	

Table 40: Centralization vs. Decentralization – Simulation indicators

Analyzing the organization as a whole, as well as the different units that were studied utilizing also different theoretical perspectives, Tables 41 and Table 42 are created. As the hospital is a very complex institution where there are many stakeholders (internal and external) with various interests, and different resources are required in order to provide the best services to the patients, coordination is crucial. As it was mentioned before, McKee and Healy (2000) believe that centralization helps to manage high volumes of work, and Moch and Morse (1977) maintain that within a hospital, an organization that is functionally differentiated, requires a superior level of integration and increased coordination.

Category	Sub-category	Centralization	Decentralization
Integration of resource management	equipment	X	
	upstream physical resources (ICU beds)	X	
	downstream surgical resources	X	
OR rooms	staff schedule	X	
	equipment	X	
OR time allocation	top to bottom	X	
	within a unit	X	X
	schedule	X	
Financial agenda	patients	X	
	surgeons		X
	nurses		X
	booking	X	
	hospital management	X	X

Table 41: Centralization vs. Decentralization – The hospital (part 1)

Category	Centralization	Decentralization
Patients receiving the surgery (sequencing)		X
Sharing patients		X
Patient swapping capabilities		X
High variability for surgical times	X	
Standardized procedures	X	
Low variability of surgical procedures	X	
High number of interactions within and between units		X
High variability in work tasks		X
Organization of professionals		X
Medical hierarchy (expertise)		X
Administrative hierarchy	X	
Coordination	X	

Table 42: Centralization vs. Decentralization – The hospital (part 2)

LIMITATIONS

The present study has certain limitations. For example, the radiology department needs to be taken in consideration as many surgeries are 'delayed' due to lack of timely access to radiology. Furthermore, the anesthetists are also an important element in the process of the surgery. Even though they do not contribute a lot to the planning of the surgery, their expertise is required during the surgery. Without this resource, the surgery cannot take place. Also, they can accept the last surgery of the day or get this surgery rescheduled, resulting in cancelations.

A simulation should be built in such a way that it is able to track the patients and their respective surgeries. Having a time frame, 365 day, that was increased to 400 days in order to ensure that all historical surgeries are performed, influences certain indicators which result in high values for the latter. Additionally, the schedules of the OR nurses, the anesthetists, as well as the surgeons are not taken in consideration for this study. In order to have a clear view of OR scheduling, the schedules of all those involved in the OR should be considered.

More in-person interviews should be performed with the staff of the hospital. One crucial element that could provide additional insight in the potential conflicts and tensions between the OR nursing and other units is the additional interviews with OR nurses. Even though the OR nurse interviewed has a high administrative ranking in this unit, providing her with a clear picture of what happens nurse-wise in the OR, more direct interviews with the OR team leaders of the nurses should have been performed in order to have a clear image of the interactions of this unit.

Moreover, a cancer diagnostic was not taken in consideration during the simulations. All historical surgeries performed felt in the same category of importance; this means that the prioritization of surgeries (may it be cancer or acuity) was not taken in consideration.

This study is only limited to one general hospital in the Montreal's region and only to 5 out of 11 surgical specialties present in the hospital. A more detailed study is required taking in consideration the following aspects, just to mention a few: different hospitals which provide surgical services; multiple units within the same hospital should be correlated to different hospitals; schedules of all staff involved in the OR operations; the entire chain of pre-operative testing ending with the patient's discharge form the hospital – this would include radiology as well as ICU unit bed allocation; inclusion of emergency surgeries performed which shift the pre-planned elective surgeries.

CONCLUSION

As it has been noted by others before, there is a tendency to bureaucratize the hospital, i.e. to use the Weberian model. Yet, the administrator must take in consideration that physicians are free professionals who can *change* one organization for another. Wilson (1963, p. 74) specifically warns about this aspect as "one key problem for the future of hospital organization is the juxtaposition of this rising tide of bureaucracy and the free professional."

According to Duncan (1979), organizational design can be explained by the interactions of and between human resource, technology and tasks which ensure that the organizational objectives are being fulfilled. In such a design, mechanisms need to be expertly integrated in order to facilitate coordination between actors and sub-divisions (Mintberg, 1983). Taking this in consideration, Nadler and Tushman (1988) state that formal linkages (such as communication) need to be present to assist the coordination effort. In the present context, some aspects of scheduling planning do provide better results, such as high variability for surgical times, standardized procedures, low variability of surgical procedures, OR time and rooms allocation. These also include units with the following characteristics: many patients, short surgical duration, high number of surgeons and surgeries. All these are linked to situations that are considered uniform events by Litwak (1961). Furthermore, the informal links are also important, and in some cases crucial for the patient. It was mentioned that surgeons do swap OR time due to the arrival of an acute patient. Without good relations between surgeons, between their respective administrators, thus between units, swapping would not be possible.

The hospital needs to balance all the needs and demands of all the stakeholders. It is for this reason that certain decisions need to be taken in a decentralized manner, yet others need a centralized process. The balance mechanism falls under the centralized paradigm and consists essentially of the coordination of all the resources of the hospital. The results of the analysis show that for different units, centralization of their processes is not beneficial, especially for those that have a low number of patients and a low variability of surgical interventions/procedures. Interestingly, this is contradictory to conventional contingency theory. The key factors explaining this contradiction seem to be that (1) surgeons operate in a context where cultural and social values are strongly shared (professional), and (2) other factors that are normally better managed through centralization (physical infrastructure, availability of

personnel) become less burdensome to coordinate in a decentralized way when those working the 'shop floor' have immediate access to and better familiarity with their utilization.

Every diagnostic is different and the hospital focuses on the patient and his needs primarily and on all the patient's characteristics. The surgeons treat the patient, not the disease. According to NHS Sustainable Development Unit (2011), a sustainable healthcare system has: an approach focused more on the personal rather than the professional; a stronger emphasis on the societal wellbeing rather than on sickness; and, the use of resources in a balanced way, minimizing waste. Most of these elements are taken in consideration in the current general hospital. The only problem with the latter, regarding its ability to schedule and perform more surgeries is the budget: a larger budget would result in more nurses, more equipment, more time in the OR, more surgeries performed, all leading to shorter waiting lists and waiting times for the patients. This would answer Friedson's (1978, p. 980) statement that "the final major segment of the health system is the health consumer." The entire (healthcare) system must be set-up in such a manner as the patient receives what it needs when it needs it. It is the duty and obligation of the hospital to ensure this high standard goal.

In the general hospital in which this study was performed, there is a good atmosphere between all the actors involved in the scheduling of elective surgeries, there are no tension and disagreements between the stakeholders. In other words, a strong professional culture facilitates interaction and coordination, as expressed by the work of Bunderson et al. (2000).

The simulation results do show that centralization provides better waiting times in comparison with the current decentralized method of scheduling surgeries. However, it is not only the OR time which should be considered: surgeon's schedule, OR nurses' schedule, anesthetists' schedule, equipment, calling-in sick of different members of the OR team.

If there are parameters that are predictable, having thus a low level of uncertainty, centralization is recommended; however, if there are variable factors not known in advance, decentralization is a good decision structure. This is valid for the entire hospital as an organization, including the units and sub-units involved as the variability of the work performed include different tasks to be carried out. The latter aspect creates differences in the coordination required to have a balanced system. These can be easily seen in Tables 40, 41 and 42 as the higher the hierarchy or having a central position (booking agent) requires centralization of decision making and resource allocation. However, at the lower levels of the hierarchy where

decisions need to be taken rapidly combining different important patient characteristics, decentralization provides a better structure.

In order to have a definitive verdict if centralization is required in a hospital, a few aspects must be considered:

1. Centralization may not be beneficial for all the surgical units;
2. The analysis must be focused on a specific unit;
3. Additional indicators must be considered, not only patient waiting time, idle time and over time of the OR;
4. Hospital management must have clear thresholds in order to determine if one scenario is better than another.

A more in-depth analysis of all the stakeholders, comprising also of all the elements which affect the scheduling and performance of a surgery, should be undertaken in order to have a better view of all the interactions which take place between actors and units, in order to reduce the elective surgery waiting time of patients. However, an important feature of centralized system that should be incorporate is the capability to be manually updated and adjusted the system, which is essential in special cases.

REFERENCES

- Aldrich, H. E., 1975. *Organizations and environments*. Prentice-Hall.
- Aletras, V., Jones, A., Sheldon, T. A., 1997. Economies of scale and scope. In Ferguson, B., Sheldon, T., Posnett, J. (Eds.), *Concentration and choice in health care*. p. 23-36. Royal Society of Medicine Press.
- Amblard, H., Bernoux, P., Herreros, G., Livian, Y-F., 1996. *Les nouvelles approches sociologiques des organisations.* Editions du Seuil.
- Anderson, T. R., Warkov, S., 1961. Organizational size and functional complexity: a study of administration in hospitals. *American Sociological Review*, 26(1), p. 23-28.
- Aoki, M., 1986. Horizontal vs. vertical information structure of the firm. *American Economic Review,* 76, p. 971-983.
- Azari-Rad, S., Yontef, A. L., Aleman, D. M., Urbach, D. R., 2013. Reducing elective general surgery cancellations at a Canadian hospital. *Canadian Journal of Surgery*, 56(2), p. 113-118
- Bamford, D., Griffin, M., 2008. A case study into operational team-working within a UK hospital. *International Journal of Operations and Production Management*, 28(3), p. 215-237.
- Banks, J., Carson II, J. S., Nelson, B. L., Nicol, D. M., 2005. *Discrete-event system simulation*. 4th edition. Pearson Prentice Hall.
- Barley, S. R., Tolbert, P. S., 1991. Introduction: at the intersection of organizations and occupations. In Barley, S. R., Tolbert, P. S. (Eds.), *Research in the sociology of organizations*, p. 1-13. JAI Press.
- Barzun, J., 1978. The Professions under Siege. *Harper's*, 257, p. 61-68.
- Bates, F. L., White, R. F., 1961. Differential perceptions of authority in hospitals. *Journal of Health and Human Behavior*, 2, p. 262-267.
- Beardwood, B., Walters, V., Eyles, J., French, S., 1999. Complaints against nurses: a reflection of `the new managerialism' and consumerism in health care? *Social Science and Medicine*, 48, p. 363-374.
- Becker, S. W., Stafford, F., 1967. Some Determinants of Organizational Success. *The Journal of Business*, 40(4), p. 511-518.
- Berger, J., Ridgeway, C. L., Fisek, H., Norman, R. Z., 1998. The legitimation and delegitimation of power and prestige orders. *American Sociological Review*, 63, p. 379-405
- Blau, P. M., Schoenherr, R., 1971. *The structure of Organizations*. Basic Books.
- Blau, P. M., Scott, W. R., 1962. *Formal Organizations*. Chandler.
- Borgatti, S. P., Halgin, D. S., 2011. On network theory. *Organization Science*, 22, p. 1168-1181.
- Bourgeois, L. J., 1984. Strategic management and determinism. *The Academy of Management Review*, 9(4), p. 586-596.
- Brandao de Souza, L., 2009. Trends and approaches in lean healthcare. *Leadership in Health Services*, 22(2), p. 121-139.
- Broome, J. 1999. *Ethics out of Economics*. Cambridge University Press.

- Brown, J. S., Duguid, P., 1991. Organizational learning and communities of practice: Toward a unified view of working, learning, and innovation. *Organization Science*, *2*(1), p. 40-57.
- Bucher, R., Stelling. J., 1969. Characteristics of professional organizations. *Journal of Health and Social Behavior*, 10, p. 3-15.
- Burns, T., Stalker, G. M., 1961. *The management of innovation.* Tavistock Publications.
- Burton, R. M., Lauridsen, J., Obel, B., 2000. Fit and misfits in the multidimensional contingency model: an organizational change perspective. Working paper. Research Center for Management, Organization, and Competence.
- Burton, R. M., Obel, B., 1998. *Strategic Organizational Diagnosis and Design. Developing Theory for Application.* Second Edition. Kluwer Academic Publishers.
- Bunderson, J. S., Lofstrom, S. M., Van De Ven, A. H., 2000. Conceptualizing and measuring professional and administrative models of organizing. *Organizational Research Methods*, 3(4), p. 366-391.
- Campbell, L., 1980. Clinical and managerial aspects of hospital admission. *British Medical Journal*, 281(6242), p. 748.
- Campbell, M., 1994. The structure of stress in nurses' work. In Bolaria, B. S., Dickinson, H. D. (Eds.), *Health, Illness, and Health Care in Canada, 2nd ed*., p. 592-608. Harcourt Brace and Co.
- Canadian Institute for Health Information (2012). *National Health Expenditure Trend 1975 to 2012*. Accessed on 20 October, 2015. Accessed from: <https://secure.cihi.ca/free_products/NHEXTrendsReport2012EN.pdf>
- Cannon-Bowers, J. A., Salas, E., Converse, S. A., 1993. Shared mental models in expert decision-making teams. In Castellan, N. J. Jr. (Ed.), *Current issues in individual and group decision making*, p. 221-246. Lawrence Erlbaum Associates.
- Carr-Saunders, A.M., Wilson, P. A., 1933. *The Professions*. Clarendon Press.
- Chandler, A., 1962. *Strategy and structure*. Doubleday.
- Chatziaslan, E., Bamford, D., 2005. Matching demand and capacity of patient services within the UK National Health Service. *Proceedings of EurOMA 2005 Conference*, Budapest-Hungary, p. 2159-2168.
- Chervenak, F. A., McCullough, L. B., 2001. The moral foundation of medical leadership: The professional virtues of the physician as fiduciary of the patient. *American Journal of Obstetrics and Gynaecology*, 184, p. 875-880.
- Child, J., 1972. Organization structure, environment and performance: the role of strategic choice. *Sociology*, 6, p. 1-22.
- Child, J., 1973. Predicting and understanding organizational structure. *Administrative Science Quarterly*, 18, p. 168-185.
- Child, J., 1973a. *Man and organization*. Allen and Unwin.
- Choiniere, J., 1993. A case study examination of nurses and information technology. In Armstrong, P., Choiniere, J., Day, E. (Eds.), *Vital Signs: Nursing in Transition*, p. 59-87. Garamond Press.
- Comstock, D. E., Scott, W. R., 1977. Technology and the structure of subunits: distinguishing individual and workgroup effects. *Administrative Science Quarterly*, 22(2), p. 177-202.

- Creteur, M., Pochet, Y., 2003. Organizational design and hospital performance. Working paper. Accessed on 25 December, 2015. Accessed from: <https://www.uclouvain.be/cps/ucl/doc/iag/documents/WP_51_creteur.pdf>
- Daft, R. L., 1991. *Management*. Second edition. The Dryden Press.
- Dahl, R., 1957. The Concept of Power. *Behavioral Science*, 2, p. 201-215.
- Davis, G. F., Marquis, C., 2005. Prospects for organization theory in the early twenty-first century: Institutional fields and mechanisms. *Organization Science*, 16(4), p. 332-343.
- Deb, K., 2001. *Multi objective optimization using evolutionary algorithms*. Wiley.
- DiMaggio, P. J., Powell, W. W., 1983/1991. The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, 48, p. 147-160. And in Powell, W. W., DiMaggio, P. J. (Eds.), *The new institutionalism in organizational analysis*, p. 63-82. University of Chicago Press.
- DiTomaso, N., Post, C., Parks-Yancy, R., 2007. Workforce diversity and inequality: power, stats and numbers. *Annual Review of Sociology*, 33, p. 473-501.
- Donaldson, L., 2001. *The contingency theory of organisations*. Sage Publications.
- Duncan, R., 1979. What is the right organization structure? Decision tree analysis provides the answer. *Organizational Dynamics*, 7(3), p. 59-80.
- Eakin, J. M., 1984. Hospital power structures and the democratization of hospital administration in Quebec. *Social Science and Medicine* 18(3), p. 221-228.
- Eisenhardt, K. M., 1989. Agency theory: an assessment and review. *The Academy of Management Review*, 14(1), p. 57-74.
- Engel, G. V., 1969. The effect of bureaucracy on the professional authority of the physician. *Journal of Health and Social Behavior* 10(1), p. 30-41.
- Etzioni, A. (Ed.), 1969. *The semi-professions and their organization*. Free Press.
- Fiore, S. M., Salas, E., 2004. Why we need team cognition. In Salas, E., Fiore, S. M. (Eds.), *Team cognition: Understanding the factors that drive process and performance*, p. 235-248. APA Books.
- Forrester, J. W., 1980. Systems dynamics – Future opportunities. *TIMS Studies in the Management Sciences*, 14, p. 7–21.
- Freidson, E., 1968. The Impurity of Professional Authority. In Becker, H.S., Geer, B., Riesman, D., Weiss, R.S. (Eds.), *Institutions and the Person*, p. 25-34. Aldine.
- Freidson, E., 1970. *Profession of medicine*. Mead.
- Friedson, E., 1978. The prospects for health services in the United States. *Medical Care*, 16(12), p. 971-983.
- Freidson, E., Rhea, B., 1963. Processes of control in a company of equals. *Social Problems*, 11, p. 119-130.
- Galbraith, J., 1973. *Designing complex organizations*. Addison-Wesley.
- Gersick, C. J. G., 1988. Time and transition in work teams: toward a new model of group development. *Academy of Management Journal*, 41, p. 9-41.
- Gersick, C. J. G., Hackman, J. R., 1990. Habitual routines in task-performing groups. *Organizational Behavior and Human Decision Processes*, 47, p. 65-97.
- Gibson, C. B., 2001. From accumulation to accommodation: the chemistry of collective cognition in work groups. *Journal of Organizational Behavior*, 22, p. 121-134.

- Goldstein, M. S., 1984. Abortion as a medical career choice: entrepreneurs, community physicians, and others. *Journal of Health and Social Behavior*, 25, p. 211-229.
- Gouldner, A. W., 1957. Cosmopolitans and locals: toward an analysis of latent social roles—I. *Administrative Science Quarterly*, 2(3), p. 281-306.
- Greenwood, R., Hinings, C. R., Ranson, S., 1977. The politics of the budgetary process in English local government. *Political Studies*, 25, p. 25-47.
- Gunasekaran, A., Forker, L., Kobu, B., 2000. Improving operations performance in a small company: a case study. *International Journal of Operations and Production Management*, 20(3), p. 316-335.
- Hackman, J. R., Morris, C. G., 1975. Group tasks, group interaction processes, and group performance effective ness: a review and proposed integration. *Advances in Experimental Psychology*, 8, p. 45-99.
- Hage, J., Dewar, R., 1973. Elite values versus organizational structure in predicting innovation. *Administrative Science Quarterly*, 18(3), p. 279-290.
- Hall, R. H., 1968. Proffesionalization and bureaucratization. *American Sociological Review*, 33, p. 92-104.
- Hall, R., 1972. *Organizations: structure and process*. Prentice-Hall.
- Hewett, D. G., Watson, B. M., Gallois, C., Ward, M., Leggett, B. A., 2009. Intergroup communication between hospital doctors: implications for quality of patient care. *Social Science and Medicine*, 69, p. 1732-1740.
- Heydebrand, W. V., 1973. *Hospital bureaucracy: a comparative study of organizations*. Dunellen Press.
- Kast, F. E., Rosenzweig, J. E., 1974. *Organization and management: a systems approach*. 2nd ed. McGraw-Hill.
- Kelly, A., 1991. The enterprise culture and the welfare state: restructuring the management of the health and personal social services. In Burrows, R. (Ed.), *Deciphering the Enterprise Culture*, p. 126-151. Routledge.
- Kinston, W., 1983. Hospital organization and structure and its effect on inter-professional behaviour and the delivery of care. *Social Science and Medicine*, 17(16), p. 1159-1170.
- Klimoski, R. J., Mohammed, S., 1994. Team mental model: construct or metaphor? *Journal of Management*, 20, 403-437.
- Kraiger, K., Wenzel, L. C., 1997. Conceptual development and empirical evaluation of measures of shared mental models as indicators of team effectiveness. In Brannick, M. T., Salas, E., Prince, C. (Eds.), *Team performance assessment and measurement: Theory, methods, and applications*, p. 45-84. Lawrence Erlbaum Associates.
- Lawrence, P., Lorsch, J., 1967. *Organization and environment*. Harvard University Graduate School of Business Administration.
- Lega, F., DePietro, C., 2005. Converging patterns in hospital organization: beyond the professional bureaucracy. *Health Policy*, 74, p. 261-281.
- Levitt, R. E., Thomsen, J., Christiansen, T. R., Kunz, J. C., Jin, Y., Nass, C., 1999. Simulating project work processes and organizations: toward a micro-contingency theory of organizational design. *Management Science*, 45(11), p. 1479–1495.
- Light, D., Levine, S., 1988. The changing character of the medical profession: a theoretical overview. *The Milbank Quarterly*, 66(2), p. 10-32.

- Litwak, E., 1961. Models of bureaucracy which permit conflict. *American Journal of Sociology*, 67(2), p. 177-184.
- Luthans, F., Stewart, T. I., 1977. A general contingency theory of management. *The Academy of Management Review*, 2(2), p. 181-195.
- March, J. G., Simon, H. A., 1958. *Organizations*. John Wiley & Sons.
- Marcson, S., 1960. *The Scientist in American Industry*. Harper.
- Marks, M. A., Sabella, M. J.,Burke, C. S., Zaccaro, S. J., 2002. The impact of cross-training on team effectiveness. *Journal of Applied Psychology*, 87, p. 3-13.
- Marks, M. A., Zaccaro, S. J., Mathieu, J. E., 2000. Performance implications of leader briefings and team-interaction training for team adaptation to novel environments. *Journal of Applied Psychology*, 85, p. 971-986.
- Martin, M. D., 1980. How to manage yourself and the surveyor. *Health Care Management Review*, 5(3), p. 67-70.
- Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Salas, E., Cannon-Bowers, J., 2000. The influence of shared mental models on team process and performance. *Journal of Applied Psychology*, 85, p. 273-283.
- Mauksch, H. O., 1973. Ideology, interaction and patient care in hospitals. *Social Science and Medicine,* 7, p. 817-830.
- McGurran, J., 2013. Chapter 5: Canada. In Siciliani, L., Borowitz, M., Moran, V. (Eds.), *Waiting Time Policies in the Health Sector: What Works?, OECD Health Policy Studies*, OECD Publishing.
- McKee, L., 1988. Conflicts and context in managing the closure of a large psychiatric. *Psychiatric Bulletin*, 12, p. 310-319.
- McKee, M. R., 1970. To superintend the sick: a role analysis of the hospital administrator. *Sociological Focus* 3(4), p. 25-41
- McKee, M., Healy, J., 2000. The role of the hospital in a changing environment. Bulletin of the World Health Organization, 78(6), p. 803-810.
- McKinlay, J. B., Stoeckle, J. D., 1988. Corporatization and the social transformation of doctoring. International *Journal of Health Services*, 18(2), p. 191-205.
- Mechanic, D., 1973. The sociology of organizations. In: Feldman, S. (Ed.), *The Administration of Mental Health Services*, p. 138-166. Charles C Thomas.
- Mechanic, D., Aiken, L. H., 1982. Sounding board. A cooperative agenda for medicine and nursing. *New England Journal of Medicine*, 307(12), p. 747–50.
- Miller, D., 1992. Environmental fit versus internal fit. *Organization Science*, 3(2), p. 159-178.
- Mintzberg, H., 1980. Structure in 5's: a synthesis of the research on organization design. M*anagement Science*, 26(3), p. 322-341.
- Mintzberg, H., 1982. *Structure et dynamique des organisation*. Edition d'organisation/Agence d'Arc.
- Mintzberg, H., 1983. *Structuring in fives: designing effective organization*. Prentice-Hall.
- Moch, M. K., Morse, E. V., 1977. Size, centralization and organizational adoption of innovations. *American Sociological Review*, 42(5), p. 716-725.
- Nadler, D., Hackman, J. R., Lawler, E., 1979. *Managing organizational behavior.* Little Brown and Company.

- Nadler, D., Tushman, M., 1988. *Strategic organization design: concepts, tools and processes.* Scott, Foresman and Company.
- Navarro, V., 1976. *Medicine under capitalism*. Prodist.
- Navarro, V., 1986. *Crisis, health and medicine*. Tavistock.
- Naylor, T. H., Balintfy, J. L., Burdick, D. S., Chu, K., 1966. *Computer simulation techniques*. Wiley.
- Nettleton, S., 1995. *The Sociology of Health and Illness*. Polity Press.
- NHS Sustainable Development Unit, 2011. *Route Map For Sustainable Health*. NHS Sustainable Development Unit, Cambridge.
- Parsons, T., 1947. Introduction. In Henderson, A. M., Parsons, T. (Eds. and Trans.), *Max Weber, theory of social and economic organization*, p. 58-60. Oxford University Press.
- Peeples, E. H., Francis, G. M., 1968. Social-psychological obstacles to effective health team practice. *Nursing Forum* 7(1), p. 28-37.
- Perrow, C., 1961. The analysis of goals in complex organizations. *American Sociological Review*, 26(6), p. 854-866.
- Pugh, D. S., Hickson, D. J., Hinings, C. R., 1968. Dimensions of organization structure. *Administrative Science Quarterly,* 13, p. 62-70.
- Pugh, D. S., Hickson, D. J., Hinings, C. R., 1969a. The context of organization structures. *Administrative Science Quarterly,* 14, p. 91-114.
- Pugh, D. S., Hickson, D. J., Hinings, C.R., 1969b. An empirical taxonomy of structures of work organizations. *Administrative Science Quarterly,* 14, p. 115-126.
- Pugh, D. S., Pheysey, D. C., 1968. Some developments in the study of organizations. *Management International Review,* 8, p. 97-108.
- Quinn, R. E., Rohrbaugh, J., 1983. A spatial model of effectiveness criteria: towards a competing values approach to organizational analysis. *Management Science*, 29(3), p. 363-377.
- Radnor, Z. J., Boaden, R., 2008. Lean in public services e Panacea or Paradox? *Public Money and Management*, 28(1), p. 3-7.
- Radnor, Z. J., Holweg, M., Waring, J., 2012. Lean in healthcare: the unfilled promise? *Social Science and Medicine*, 74, p. 364-371
- Ranson, S., Hinings, B., Greenwood, R., 1980. The structuring of organizational structures. *Administrative Science Quarterly*, 25(1), p. 1-17.
- Reay, T., Hinings, C. R., 2005. The recomposition of an organizational field: Health care in Alberta. *Organizations Studies*, 26(3), p. 351-384.
- Reeves, T. K., Woodward, J., 1970. The study of managerial control. In Woodward, J. (Ed.), *Industrial organization: behaviour and control*, p. 37-56, Oxford University Press.
- Relman, A. S., 1985. Dealing with conflicts of interest. *New England Journal of Medicine*, 313(12), p. 749-751.
- Rico, R., Sanchez-Manzanares, M., Gil, F., Gibson, C., 2008. Team implicit coordination processes: a team knowledge-based approach. *The Academy of Management Review*, 33(1), p. 163-184.
- Ridgeway, C. L., 1991. The social construction of status value: gender and other nominal characteristics. *Social Forces*, 70, p. 367-386.
- Ridgeway, C. L., 1994. External status, legitimacy, and compliance in male and female groups. *Social Forces*, 72, p. 1051-1077.

- Ridgeway, C. L, Boyle, E. H., Kuipers, K. J., Robinson, D. T., 1998. How do status beliefs develop? The role of resources and interactional experiences. *American Sociological Review*, 63, p. 331-350.
- Sachdev, I., Bourhis, R. Y., 1991. Power and status differentials in minority and majority group relations. *European Journal of* Social *Psychology*, 21, p. 1-24.
- Satow, R. L., 1975. Value-rational authority and professional organizations: Weber's missing type. Administrative Science Quarterly, 20(4), p. 526-531.
- Schroeder, K., Thompson, T., Frith, K., Pencheon, D., 2013. *Sustainable Healthcare*. Wiley Blackwell.
- Scott, W. R., 1965. Reactions to supervision in a heteronomous professional organization. *Administrative Science Quarterly*, 10, p. 65-81.
- Scott, W. R., 1995. *Institutions and organizations*. Sage.
- Scott, W. R., Volkart, E. H., 1966. *Medical Care. Readings in the sociology of medical institutions*. John Wiley Sons.
- Scull, A. T., 1979. *Museums of madness: the social organization of insanity in nineteenth-century England.* St. Martin Press.
- Shannon, R. E., 1998. Introduction to the art of simulation. In Medeiros, D. J., Watson, E. F., Carson, J. S., Manivannan, M. S. (Eds.), *Proceedings of the 1998 Winter Simulation Conference*, p. 7-14.
- Sheps, C. G., 1972. The hospital as a community facility: what gives meaning to the interdependence of hospitals. *Bulletin of New York Academy of Medicine*, 48(11), p.1481-1485.
- Thompson, J. D., 1967 *Organizations in Action*. McGraw-Hill
- Townley, B. 2002. The role of competing rationalities in institutional change. *Academy of Management*, 45(1), p. 163-179.
- Trice, H. M., 1993. *Occupational subcultures in the workplace*. Cornell ILR Press.
- Van Maanen, J., Barley, S. R., 1984. Occupational communities: culture and control in organizations. In Cummings, L. L., Staw, B. M. (Eds.), *Research in organizational behaviour*, 6, p. 287-365. JAI Press.
- Vanderwarker, R. D., 1967. Meeting demands of new health care. *Hospitals*, 41, p. 36-42.
- Vissers, J., 1998. Patient flow-based allocation of inpatient resources: a case study. *European Journal of Operational Research*, 105, p. 356-370.
- Waitzkin, H., 1983. *The second sickness: contradictions of capitalist health care*. Free Press.
- Weber, M., 1964. *The Theory of Social and Economic Organization*. Free Press.
- Weber, M., 1968. Economy and society: an outline of interpretive sociology. Bedminster Press.
- Weick, K. E., Roberts, K. H., 1993. Collective mind in organizations: heedful interrelating on flight decks. *Administrative Science Quarterly*, 38, p. 357-381.
- Weinman, M. L., Grimes, R. M., His, B. P., Justice, B., Schoolar, J. C., 1979. Organizational structure and effectiveness in general hospital psychiatry departments. *Administration in Mental Health* 7(1), p. 32-42.

- West, M. A., Borrill, C., Dawson, J., Scully, J., Carter, M., Anelay, S., Patterson, M., Waring, J., 2002. The link between the management of employees and patient mortality in acute hospitals. *International Journal of Human Resource Management*, 13(8), p. 1299-1310.
- Willer, D. E., 1967. Max Weber's missing authority type. *Sociological Inquiry*, 37, p. 231-39.
- Wilson, C., 1982. Patient-oriented management. *Health Management Forum*, 3, p. 40-57.
- Wilson, R. N., 1963. The social structure of the general hospital. *The Annals of the American Academy of Political and Social Science*, 346(1), p. 67-76.
- Womack, J. P., Jones, D. T., 1996. Beyond Toyota: how to root out waste and pursue perfection. *Harvard Business Review*, 74(5), p. 140-158.
- Woodward, J., 1965. I*ndustrial organizations: theory and practice. O*xford University Press.
- Young, D. W., Saltman, R. B., 1985. *The hospital power equilibrium. Physician behavior and cost control*. The John Hopkins University Press.
- Zabojnik, J., 2002. Centralized and decentralized decision making in organizations. *Journal of Labor Economics*, 20(1), p. 1-22.

APPENDICES

Appendix A: Aspects to be considered

"(1) Consideration should be given to the potential benefits of adopting the operational team-working paradigm, taking account of the evidence linking team-working and health quality outcomes (West et al., 2002; Gunasekaran et al., 2000).
(2) Assess the present operational structure regarding its appropriateness for patient pathway centered care, as opposed to the current organizational clusters of medical specialties.
(3) There is a need for a much clearer operational performance framework within the organization at operating unit level. A simple balanced scorecard approach (Chatziaslan and Bamford, 2005) would be easy to design and link back to group and organization objectives. The advantage of this approach would be the ease of including both clinical and managerial targets.
(4) Leadership training should be available to ensure leaders have the necessary skills to address task, team, individual and environmental needs for effective team working.
(5) Team training, learning and facilitation support should be made available. In particular, diversity management in teams requires more support.
(6) Be clear about the operational objectives in promoting team-work and communicate: raising productivity or quality standards? To encourage innovation? To engage the talents and experience of all? To facilitate a clearer performance management framework to better integrate both clinical and management objectives? Ultimately these should bridge the needs for high volume, high quality and individual patient care."

Table 43: Six messages to be considered
Bamford and Griffin 2008, p. 230

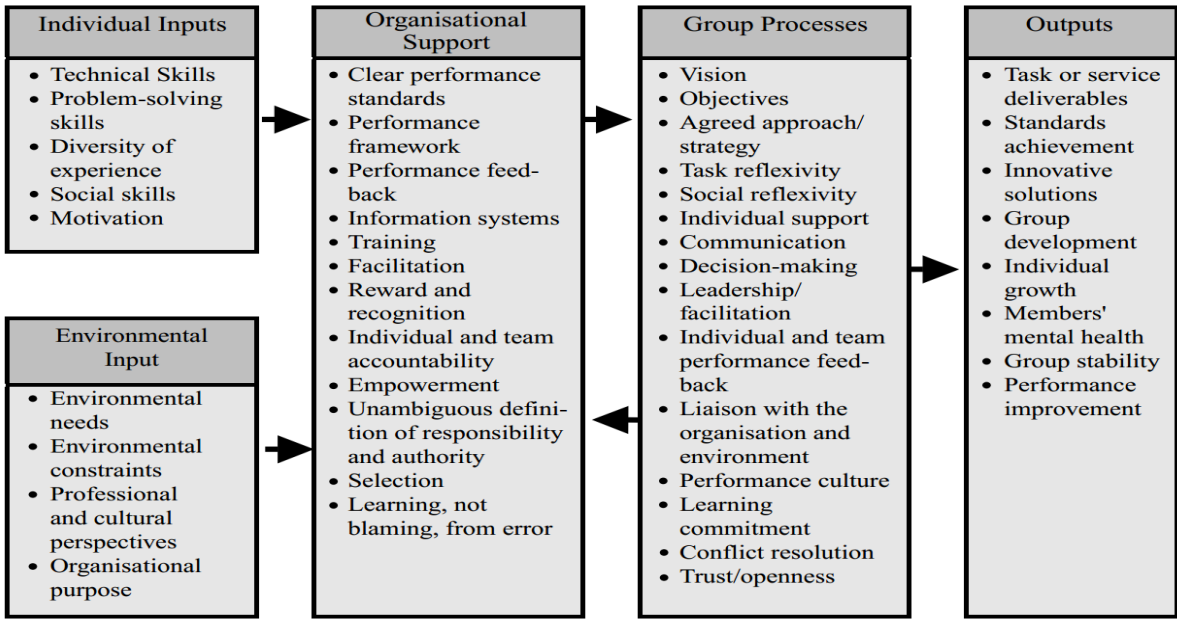


Figure 6: Input, process and output model of team effectiveness
Bamford and Griffin 2008, p. 231

Appendix B: Information and consent form

INFORMATION AND CONSENT TO PARTICIPATE IN A RESEARCH STUDY

Study Title: Reducing waiting time for elective surgeries
Researcher: Alexandru Popp
Researcher's Contact Information: Tel.: 514-487-5229. E-mail: alexwpopp@gmail.com
Faculty Supervisor: Dr. Kai Lamertz
Faculty Supervisor's Contact Information: John Molson School of Business, 1450 Guy St., MB. 14.361, Montreal, Quebec, Canada, H3H 0A1. Tel.: 514-848-2424 (ext. 4136). E-mail: kai.lamertz@concordia.ca
Source of funding for the study:

You are being invited to participate in the research study mentioned above. This form provides information about what participating would mean. Please read it carefully before deciding if you want to participate or not. If there is anything you do not understand, or if you want more information, please ask the researcher.

A. PURPOSE

The purpose of the research is the identification of any direct links between the planning procedures performed by the hospital staff and the patients' waiting time for their elective surgeries.

One of the goals of the study is to know the potential elements that influence the planning process for elective surgeries. These are directly related to how much time patients need to wait for their specific elective surgeries, as planning has a direct impact on and affects the patients' waiting time.

B. PROCEDURES

If you participate, you will be asked to participate in an interview that addresses the current procedures used to schedule elective surgeries and/or planning of the surgical schedule methodology.

In total, participating in this study will take a maximum of one hour, the duration of the interview.

As a research participant, your responsibilities are limited to your participation in an interview.

C. RISKS AND BENEFITS

There is no risk of any kind associated with the interview process.

You might or might not personally benefit from participating in this research. Potential benefits include:

- Insight and feedback that might lead to potential improvements of your tasks or tasks related to the scheduling of elective surgeries;
- A venue of providing your direct perception of how the scheduling process for elective surgeries is performed;
- Contribution to different potential improvements of the current surgical planning system;
- Your views will be incorporated in the overall analysis. Thus, your concerns and understanding of the processes will be taken in consideration;

This research is not intended to benefit you personally.

D. CONFIDENTIALITY

By participating, you agree to let the researcher(s) have access to information about the different processes involved in the planning of elective surgeries.

We will not allow anyone to access the information, except people directly involved in conducting the research, and except as described in this form. We will only use the information for the purposes of the research described in this form.

To verify that the research is being conducted properly, regulatory authorities might examine the information gathered. By participating, you agree to let these authorities have access to the information.

The information gathered will be anonymous. That means that it will not be possible to make any link between you and the information you provide. The information that you provide will be aggregated to the level of your position.

We will protect the information by the following:

- The interview will be recorded via a digital recorder. This is done to ensure accuracy of the information provided once it is transcribed.
- The interview data/information will be transferred onto a text digital format (Ms-Word), after which all the documents/papers used in the gathering of the data will be destroyed. Concordia University, under Records Management and Archives, has a secure destruction of documents program. More information about the destruction of confidential documents can be found at < http://archives.concordia.ca/shredding >
- The data files will be encrypted on a USB key, where the entire storage device is encrypted. The USB key will be able to be read only on one specific computer. As a safety precaution, a backup USB key, having the same characteristics as the main storage device is created. The backup is performed daily. Furthermore, the USB key has an additional encryption/reading contingency: all the data will be stored on biometric USB keys where the fingerprint of the researcher is required for the access to the USB key(s).

We intend to publish the results of the research. However, it will not be possible to identify you in the published results.

We will destroy the information five years after the end of the study.

F. CONDITIONS OF PARTICIPATION

You do not have to participate in this research. It is purely your decision. If you do participate, you can stop at any time. You can also ask that the information you provided not be used, and your choice will be respected. If you decide that you do not want us to use your information, you must tell the researcher before the interview.

G. PARTICIPANT'S DECLARATION

I have read and understood this form. I have had the chance to ask questions and any questions have been answered. I agree to participate in this research under the conditions described.

NAME (please print) _____

SIGNATURE _____

DATE _____

If you have questions about the scientific or scholarly aspects of this research, please contact the researcher. Their contact information is on page 1. You may also contact their faculty supervisor.

If you have concerns about ethical issues in this research, please contact the Manager, Research Ethics, Concordia University, 514.848.2424 ex. 7481 or oor.ethics@concordia.ca.

Appendix C: Interview questions

Surgeons:

- What are the patient's characteristics that are taken in consideration for the assessment for his/her surgery?
- How is the patient's waiting time (for his/her surgery) taken in consideration?
- What is the procedure to place a patient on the elective surgery waiting list?
- If a patient is already on the waiting list, yet his/her condition degrades (but not to the point of emergency), what is the procedure to 'upgrade' the patient on the waiting list (i.e. his/her placement)?
- What are the processes required for a patient to be rescheduled due to unforeseen factors?
- What is the process that a surgeon must undertake in order to secure enough OR time for his/her patients? What are the methods to allocate OR time for the surgeons and patients?
- Please describe some of the disagreements between surgeons of the same unit regarding the OR allocation and how these are settled.
- In your opinion, what are the divergences between surgical units, if there are any?
- If there are tensions between you and the surgical staff, nurses, administrative staff involved in the planning of surgical scheduling, how are these resolved?
- If there are some conflicts between units, what would those be?
- What are the remedies used and/or sanctions applied if a surgeon performs the surgery in a longer or shorter time than the time allocated for the specific surgery in the OR?
- From your perspective, what are some elements that surgeons would like to improve regarding the planning of elective surgeries?
- In your opinion, what are some elements that could be improved in the scheduling processes?

Administrators:

- What is the input that you are asked to provide to the unit regarding the elective surgical schedule?
- What is the type of scheduling method done by your unit?
- What is the rolling horizon for the elective surgery schedule in your unit?
- If a patient is already on the waiting list, yet his/her condition degrades (but not to the point of emergency), what is the procedure to 'upgrade' the patient on the waiting list (i.e. his/her placement)?
- How is the OR time allocated within your unit?
- What are the processes required for a patient to be rescheduled due to unforeseen factors?
- If surgeries are taken longer/less time than the allocated time allocated, what are the effects of these on the following surgeries, and how are these addressed?
- How is the master schedule coming together?
- From your perspective, what are some elements that the administrative staff would like to improve?
- In your opinion, what are some elements that could be improved in the scheduling processes?

Nurses:

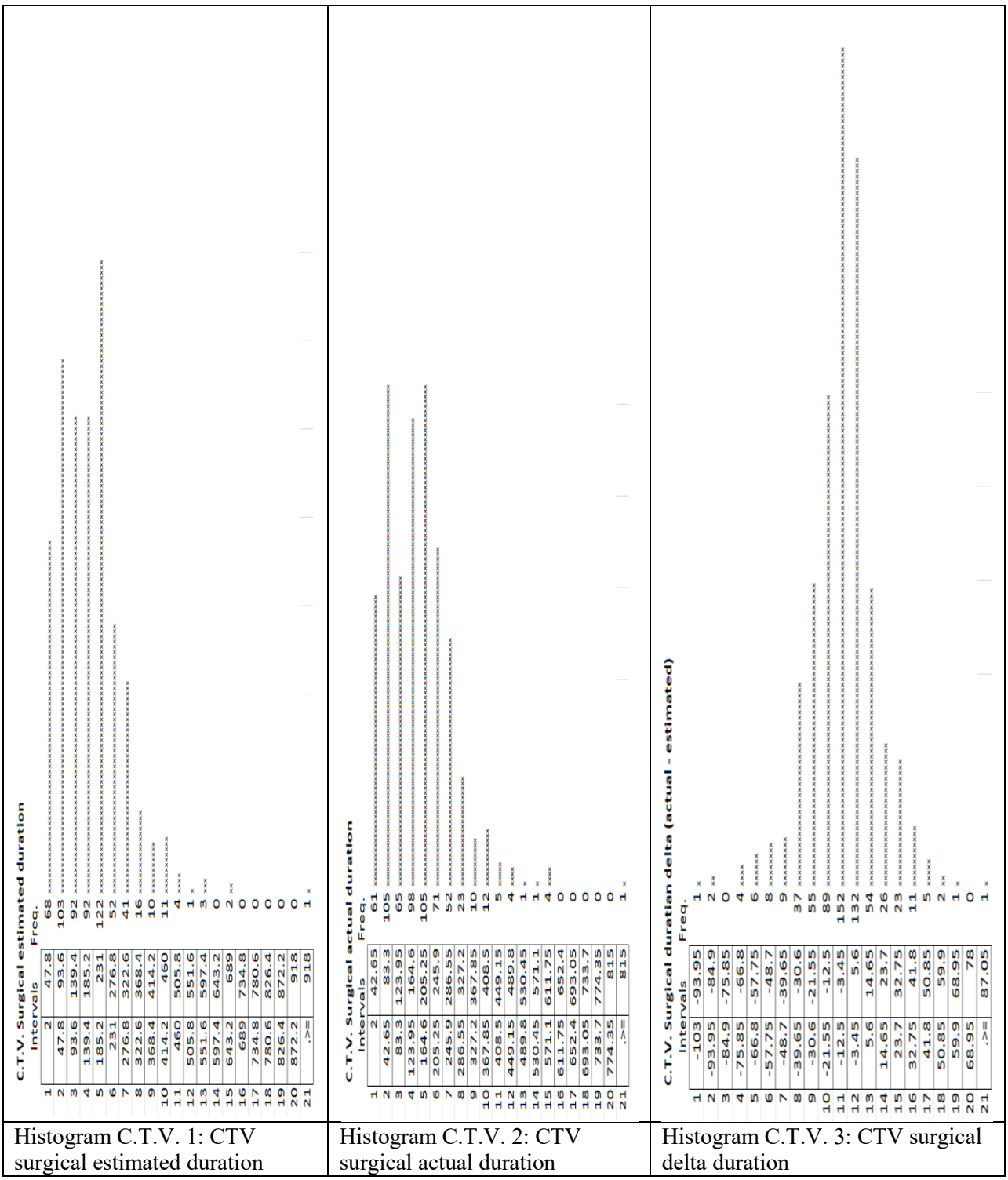
- What is your input, if any, in the assessment of a patient to be placed on the waiting list for elective surgery?
- Why would there be some conflicts between the nursing staff and the surgeons of your own unit?

- If you are aware of, please describe some of the disagreements between surgeons regarding the OR allocation and how these are settled.
- What are some potential disagreements between the staff in your unit and how are these resolved?
- What are some of the tensions that your unit might encounter with other surgical units?
- What is the type of work environment in your unit?
- From your perspective, what are some elements that the nursing staff would like to improve?
- In your opinion, what are some elements that could be improved in the scheduling processes?

Appendix D: Coding categories

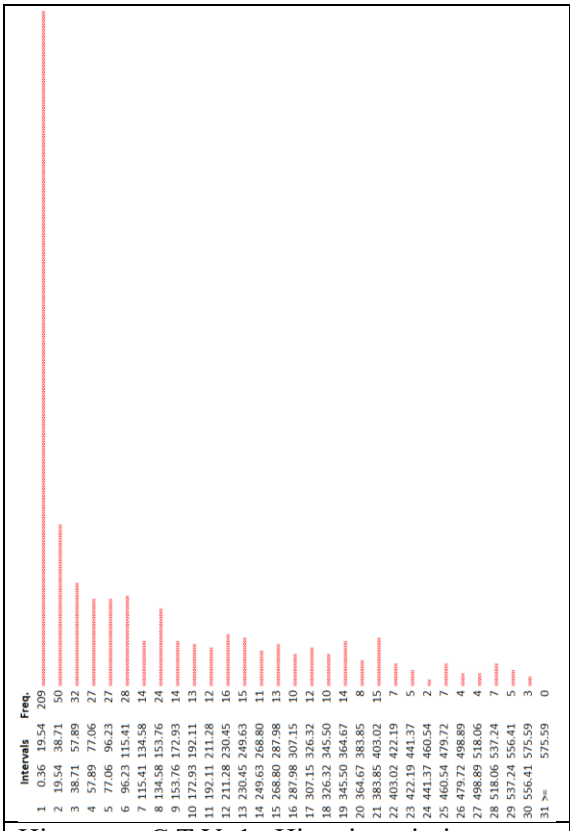
Scheduling	any information related to the scheduling of patients
In unit tensions	are there tensions present or not in the unit
Out unit tensions	are there any tensions between units or surgeons of other units
Surgery	additional information about surgeries
Centralization	is centralization good or bad
Decentralization	is decentralization good or bad
Interactions	interactions between actors
Impediments	any impediments to the system
Improvements	any improvements to the system
Admin. in unit	is there an administrator in the unit that takes care of the OR allocation
Allocation of OR	how is the OR allocated and distributed between the surgeons of a unit
Unit administration	aspects in which the unit is administered/managed
Problems in the unit	any problems/issues that exist in the unit
Problems in the hospital	any problems/issues that exist in the hospital
Hospital administration	aspects in which the hospital is administered/managed
Other	any other aspects
Surgeons	aspects related to surgeons: what they want; do not want
Nurses	aspects related to nurse: what they want; do not want
Admin.	aspects related to administrators: what they want; do not want

Appendix E: Surgical actual and estimated time



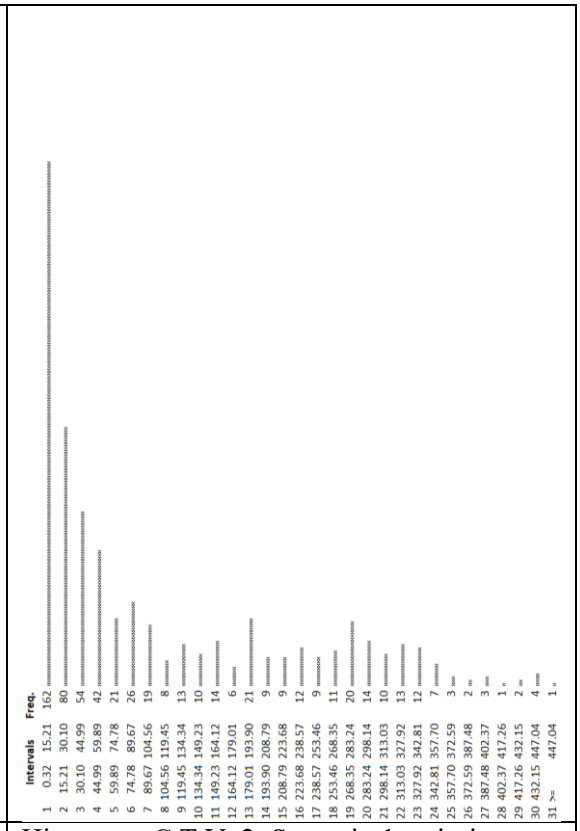
Histogram C.T.V. 1: CTV surgical estimated duration	Histogram C.T.V. 2: CTV surgical actual duration	Histogram C.T.V. 3: CTV surgical delta duration

Appendix F1: Wait times C.T.V.



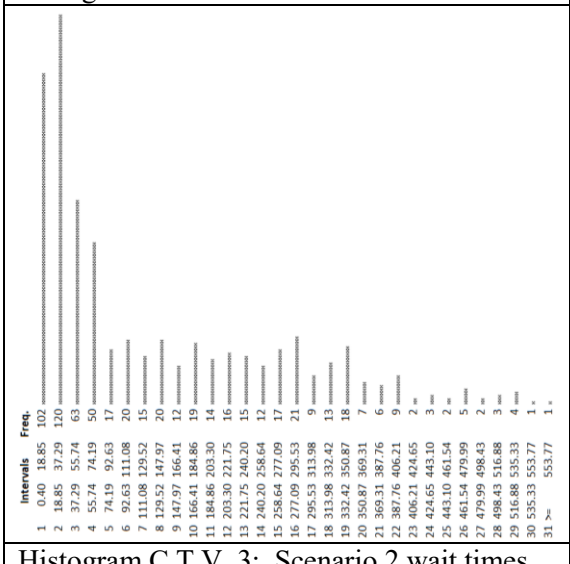
	Intervals		Freq.
1	0.40	18.85	102
2	18.85	37.29	120
3	37.29	55.74	63
4	55.74	74.19	50
5	74.19	92.63	17
6	92.63	111.08	20
7	111.08	129.52	15
8	129.52	147.97	20
9	147.97	166.41	12
10	166.41	184.86	19
11	184.86	203.30	14
12	203.30	221.75	16
13	221.75	240.20	15
14	240.20	258.64	12
15	258.64	277.09	17
16	277.09	295.53	21
17	295.53	313.98	9
18	313.98	332.42	13
19	332.42	350.87	18
20	350.87	369.31	7
21	369.31	387.76	6
22	387.76	406.21	9
23	406.21	424.65	2
24	424.65	443.10	3
25	443.10	461.54	2
26	461.54	479.99	5
27	479.99	498.43	2
28	498.43	516.88	3
29	516.88	535.33	4
30	535.33	553.77	1
31	>=	553.77	1

Histogram C.T.V. 1: Historic wait times



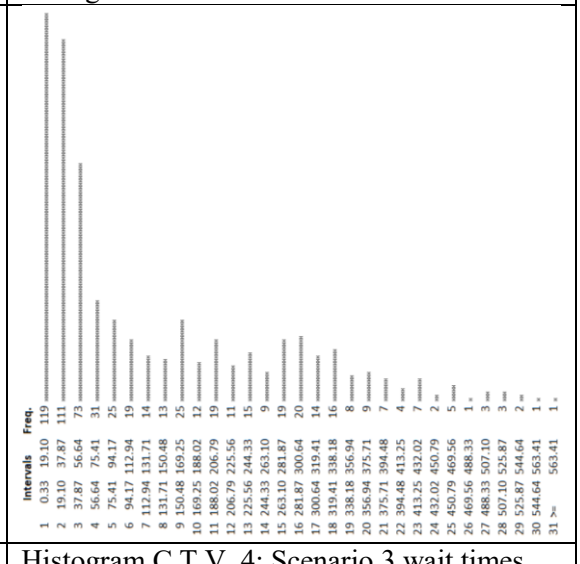
	Intervals		Freq.
1	0.36	19.54	209
2	19.54	38.71	50
3	38.71	57.89	32
4	57.89	77.06	27
5	77.06	96.23	27
6	96.23	115.41	28
7	115.41	134.58	14
8	134.58	153.76	24
9	153.76	172.93	14
10	172.93	192.11	13
11	192.11	211.28	12
12	211.28	230.45	16
13	230.45	249.63	15
14	249.63	268.80	11
15	268.80	287.98	13
16	287.98	307.15	10
17	307.15	326.32	12
18	326.32	345.50	10
19	345.50	364.67	14
20	364.67	383.85	8
21	383.85	403.02	15
22	403.02	422.19	7
23	422.19	441.37	5
24	441.37	460.54	2
25	460.54	479.72	7
26	479.72	498.89	4
27	498.89	518.06	4
28	518.06	537.24	7
29	537.24	556.41	5
30	556.41	575.59	3
31	>=	575.59	0

Histogram C.T.V. 2: Scenario 1 wait times



	Intervals		Freq.
1	0.32	15.21	162
2	15.21	30.10	80
3	30.10	44.99	54
4	44.99	59.89	42
5	59.89	74.78	21
6	74.78	89.67	26
7	89.67	104.56	19
8	104.56	119.45	8
9	119.45	134.34	13
10	134.34	149.23	10
11	149.23	164.12	14
12	164.12	179.01	6
13	179.01	193.90	21
14	193.90	208.79	9
15	208.79	223.68	9
16	223.68	238.57	12
17	238.57	253.46	9
18	253.46	268.35	11
19	268.35	283.24	20
20	283.24	298.14	14
21	298.14	313.03	10
22	313.03	327.92	13
23	327.92	342.81	12
24	342.81	357.70	7
25	357.70	372.59	3
26	372.59	387.48	2
27	387.48	402.37	3
28	402.37	417.26	1
29	417.26	432.15	2
30	432.15	447.04	4
31	>=	447.04	1

Histogram C.T.V. 3: Scenario 2 wait times

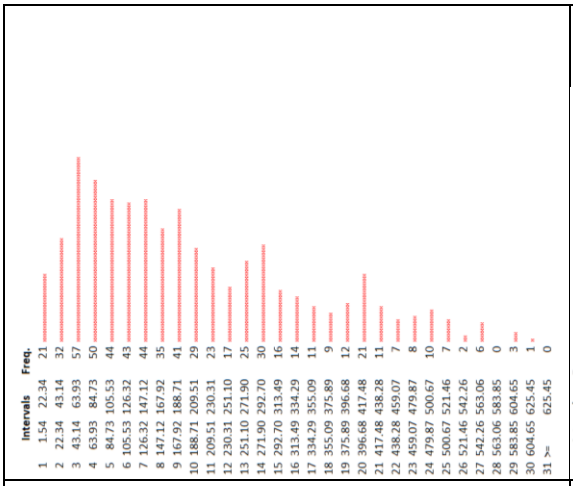


	Intervals		Freq.
1	0.33	19.10	119
2	19.10	37.87	111
3	37.87	56.64	73
4	56.64	75.41	31
5	75.41	94.17	25
6	94.17	112.94	19
7	112.94	131.71	14
8	131.71	150.48	13
9	150.48	169.25	25
10	169.25	188.02	12
11	188.02	206.79	19
12	206.79	225.56	11
13	225.56	244.33	15
14	244.33	263.10	9
15	263.10	281.87	19
16	281.87	300.64	20
17	300.64	319.41	14
18	319.41	338.18	16
19	338.18	356.94	8
20	356.94	375.71	9
21	375.71	394.48	7
22	394.48	413.25	4
23	413.25	432.02	7
24	432.02	450.79	2
25	450.79	469.56	5
26	469.56	488.33	1
27	488.33	507.10	3
28	507.10	525.87	3
29	525.87	544.64	2
30	544.64	563.41	1
31	>=	563.41	1

Histogram C.T.V. 4: Scenario 3 wait times

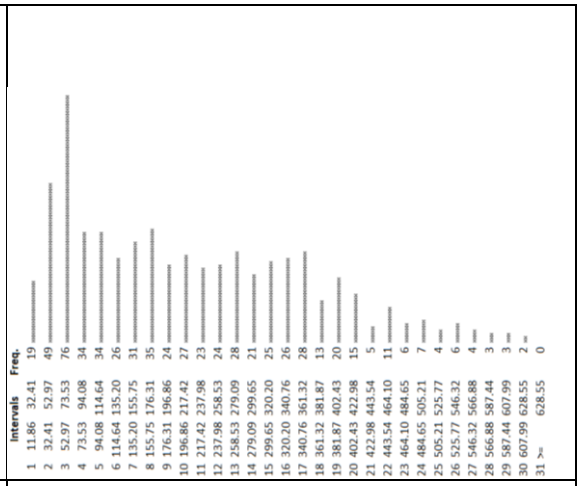
Histogram C.T.V. 0: Historical and scenarios results per patient

Appendix F2: Wait times E.N.T.



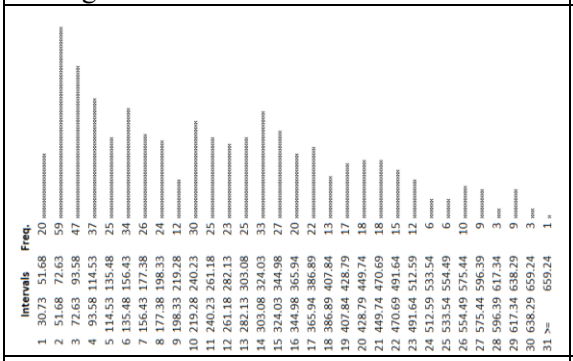
	Intervals	Freq.
1	1.54 22.34	21
2	22.34 43.14	32
3	43.14 63.93	57
4	63.93 84.73	50
5	84.73 105.53	44
6	105.53 126.32	43
7	126.32 147.12	44
8	147.12 167.92	35
9	167.92 188.71	41
10	188.71 209.51	29
11	209.51 230.31	23
12	230.31 251.10	17
13	251.10 271.90	25
14	271.90 292.70	30
15	292.70 313.49	16
16	313.49 334.29	14
17	334.29 355.09	11
18	355.09 375.89	9
19	375.89 396.68	12
20	396.68 417.48	21
21	417.48 438.28	11
22	438.28 459.07	7
23	459.07 479.87	8
24	479.87 500.67	10
25	500.67 521.46	7
26	521.46 542.26	2
27	542.26 563.06	6
28	563.06 583.85	0
29	583.85 604.65	3
30	604.65 625.45	1
31	>= 625.45	0

Histogram E.N.T. 1: Historical wait times



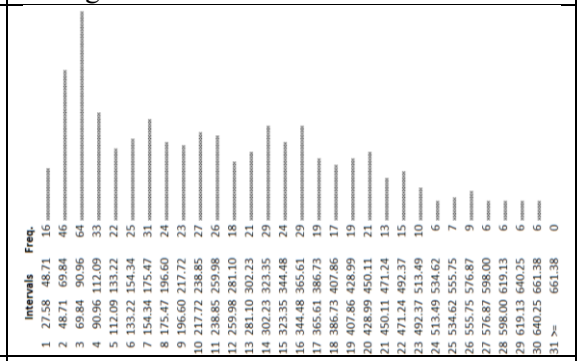
	Intervals	Freq.
1	11.86 32.41	19
2	32.41 52.97	49
3	52.97 73.53	76
4	73.53 94.08	34
5	94.08 114.64	34
6	114.64 135.20	26
7	135.20 155.75	31
8	155.75 176.31	35
9	176.31 196.86	24
10	196.86 217.42	27
11	217.42 237.98	23
12	237.98 258.53	24
13	258.53 279.09	28
14	279.09 299.65	21
15	299.65 320.20	25
16	320.20 340.76	26
17	340.76 361.32	28
18	361.32 381.87	13
19	381.87 402.43	20
20	402.43 422.98	15
21	422.98 443.54	5
22	443.54 464.10	11
23	464.10 484.65	6
24	484.65 505.21	7
25	505.21 525.77	4
26	525.77 546.32	6
27	546.32 566.88	4
28	566.88 587.44	3
29	587.44 607.99	3
30	607.99 628.55	2
31	>= 628.55	0

Histogram E.N.T. 2: Scenario 1 wait times



	Intervals	Freq.
1	30.73 51.68	20
2	51.68 72.63	59
3	72.63 93.58	47
4	93.58 114.53	37
5	114.53 135.48	25
6	135.48 156.43	34
7	156.43 177.38	26
8	177.38 198.33	24
9	198.33 219.28	12
10	219.28 240.23	30
11	240.23 261.18	25
12	261.18 282.13	23
13	282.13 303.08	25
14	303.08 324.03	33
15	324.03 344.98	27
16	344.98 365.94	20
17	365.94 386.89	22
18	386.89 407.84	13
19	407.84 428.79	17
20	428.79 449.74	18
21	449.74 470.69	18
22	470.69 491.64	15
23	491.64 512.59	12
24	512.59 533.54	6
25	533.54 554.49	6
26	554.49 575.44	10
27	575.44 596.39	9
28	596.39 617.34	3
29	617.34 638.29	9
30	638.29 659.24	3
31	>= 659.24	1

Histogram E.N.T. 3: Scenario 2 wait times

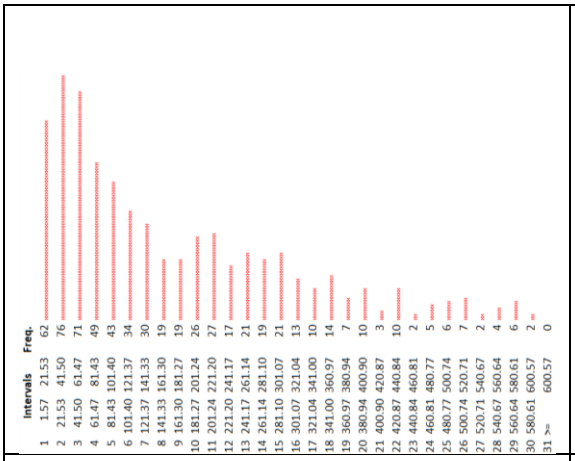


	Intervals	Freq.
1	27.58 48.71	16
2	48.71 69.84	46
3	69.84 90.96	64
4	90.96 112.09	33
5	112.09 133.22	22
6	133.22 154.34	25
7	154.34 175.47	31
8	175.47 196.60	24
9	196.60 217.72	23
10	217.72 238.85	27
11	238.85 259.98	26
12	259.98 281.10	18
13	281.10 302.23	21
14	302.23 323.35	29
15	323.35 344.48	24
16	344.48 365.61	29
17	365.61 386.73	19
18	386.73 407.86	17
19	407.86 428.99	19
20	428.99 450.11	21
21	450.11 471.24	13
22	471.24 492.37	15
23	492.37 513.49	10
24	513.49 534.62	6
25	534.62 555.75	7
26	555.75 576.87	9
27	576.87 598.00	6
28	598.00 619.13	6
29	619.13 640.25	6
30	640.25 661.38	6
31	>= 661.38	0

Histogram E.N.T. 4: Scenario 3 wait times

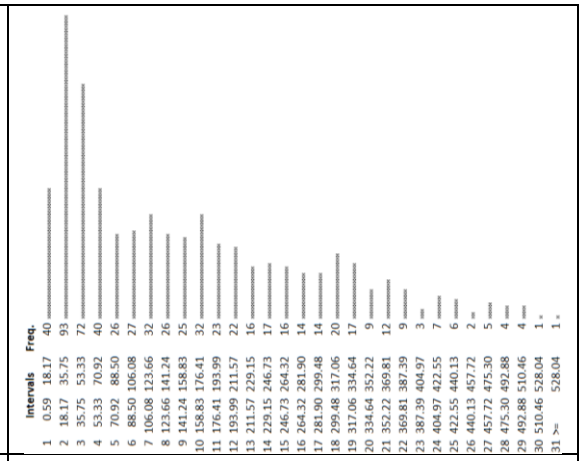
Histogram E.N.T. 0: Historical and scenarios results per patient

Appendix F3: Wait times General surgery



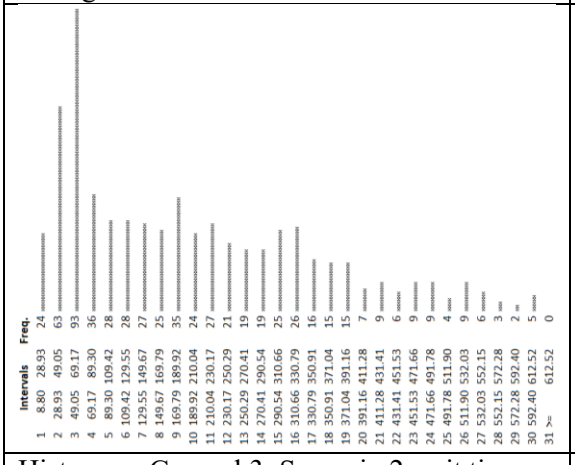
	Intervals	Freq.
1	1.57 21.53	62
2	21.53 41.50	76
3	41.50 61.47	71
4	61.47 81.43	49
5	81.43 101.40	43
6	101.40 121.37	34
7	121.37 141.33	30
8	141.33 161.30	19
9	161.30 181.27	19
10	181.27 201.24	26
11	201.24 221.20	27
12	221.20 241.17	17
13	241.17 261.14	21
14	261.14 281.10	19
15	281.10 301.07	21
16	301.07 321.04	13
17	321.04 341.00	10
18	341.00 360.97	14
19	360.97 380.94	7
20	380.94 400.90	10
21	400.90 420.87	3
22	420.87 440.84	10
23	440.84 460.81	2
24	460.81 480.77	5
25	480.77 500.74	6
26	500.74 520.71	7
27	520.71 540.67	2
28	540.67 560.64	4
29	560.64 580.61	6
30	580.61 600.57	2
31	>= 600.57	0

Histogram General 1: Historical wait times



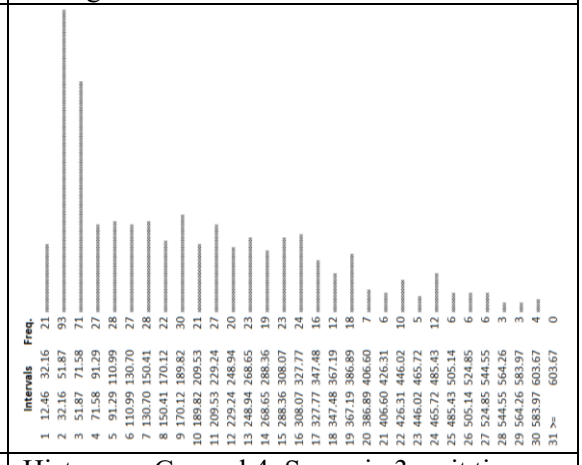
	Intervals	Freq.
1	0.59 18.17	40
2	18.17 35.75	93
3	35.75 53.33	72
4	53.33 70.92	40
5	70.92 88.50	26
6	88.50 106.08	27
7	106.08 123.66	32
8	123.66 141.24	26
9	141.24 158.83	25
10	158.83 176.41	32
11	176.41 193.99	23
12	193.99 211.57	22
13	211.57 229.15	16
14	229.15 246.73	17
15	246.73 264.32	16
16	264.32 281.90	14
17	281.90 299.48	14
18	299.48 317.06	20
19	317.06 334.64	17
20	334.64 352.22	9
21	352.22 369.81	12
22	369.81 387.39	9
23	387.39 404.97	3
24	404.97 422.55	7
25	422.55 440.13	6
26	440.13 457.72	2
27	457.72 475.30	5
28	475.30 492.88	4
29	492.88 510.46	4
30	510.46 528.04	1
31	>= 528.04	1

Histogram General 2: Scenario 1 wait times



	Intervals	Freq.
1	8.80 28.93	24
2	28.93 49.05	63
3	49.05 69.17	93
4	69.17 89.30	36
5	89.30 109.42	28
6	109.42 129.55	28
7	129.55 149.67	27
8	149.67 169.79	25
9	169.79 189.92	35
10	189.92 210.04	24
11	210.04 230.17	27
12	230.17 250.29	21
13	250.29 270.41	19
14	270.41 290.54	19
15	290.54 310.66	25
16	310.66 330.79	26
17	330.79 350.91	16
18	350.91 371.04	15
19	371.04 391.16	15
20	391.16 411.28	7
21	411.28 431.41	9
22	431.41 451.53	6
23	451.53 471.66	9
24	471.66 491.78	9
25	491.78 511.90	4
26	511.90 532.03	9
27	532.03 552.15	6
28	552.15 572.28	3
29	572.28 592.40	2
30	592.40 612.52	5
31	>= 612.52	0

Histogram General 3: Scenario 2 wait times

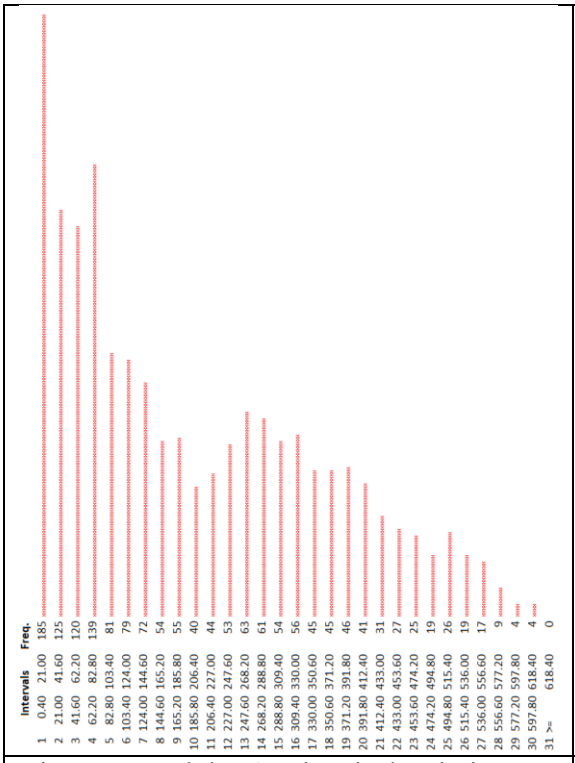


	Intervals	Freq.
1	12.46 32.16	21
2	32.16 51.87	93
3	51.87 71.58	71
4	71.58 91.29	27
5	91.29 110.99	28
6	110.99 130.70	27
7	130.70 150.41	28
8	150.41 170.12	22
9	170.12 189.82	30
10	189.82 209.53	21
11	209.53 229.24	27
12	229.24 248.94	20
13	248.94 268.65	23
14	268.65 288.36	19
15	288.36 308.07	23
16	308.07 327.77	24
17	327.77 347.48	16
18	347.48 367.19	12
19	367.19 386.89	18
20	386.89 406.60	7
21	406.60 426.31	6
22	426.31 446.02	10
23	446.02 465.72	5
24	465.72 485.43	12
25	485.43 505.14	6
26	505.14 524.85	6
27	524.85 544.55	6
28	544.55 564.26	3
29	564.26 583.97	3
30	583.97 603.67	4
31	>= 603.67	0

Histogram General 4: Scenario 3 wait times

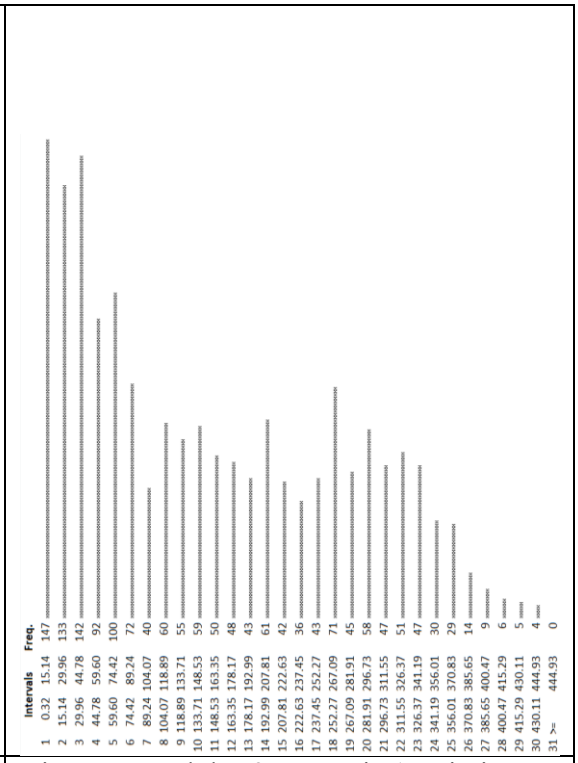
Histogram General 0: Historical and scenarios results per patient

Appendix F4: Wait times Ophthalmology surgery



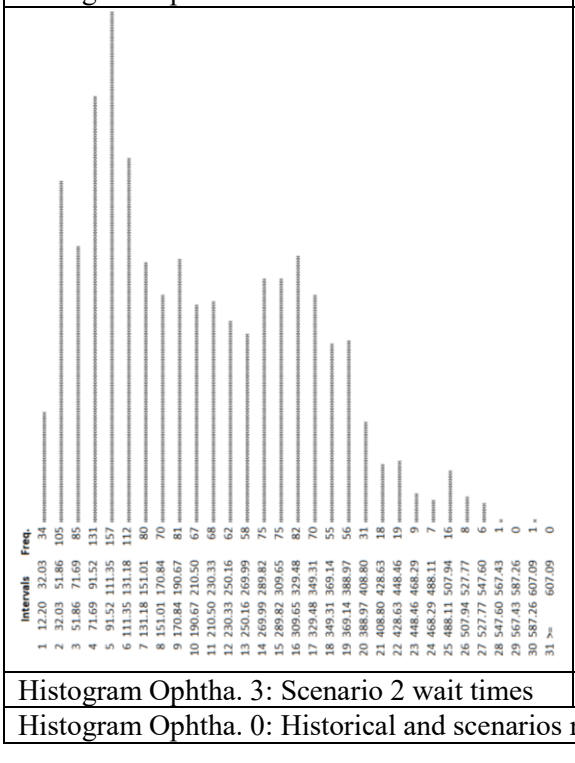
	Intervals	Freq.
1	0.40 21.00	185
2	21.00 41.60	125
3	41.60 62.20	120
4	62.20 82.80	139
5	82.80 103.40	81
6	103.40 124.00	79
7	124.00 144.60	72
8	144.60 165.20	54
9	165.20 185.80	55
10	185.80 206.40	40
11	206.40 227.00	44
12	227.00 247.60	53
13	247.60 268.20	63
14	268.20 288.80	61
15	288.80 309.40	54
16	309.40 330.00	56
17	330.00 350.60	45
18	350.60 371.20	45
19	371.20 391.80	46
20	391.80 412.40	41
21	412.40 433.00	31
22	433.00 453.60	27
23	453.60 474.20	25
24	474.20 494.80	19
25	494.80 515.40	26
26	515.40 536.00	19
27	536.00 556.60	17
28	556.60 577.20	9
29	577.20 597.80	4
30	597.80 618.40	4
31	>= 618.40	0

Histogram Ophtha. 1: Historical wait times



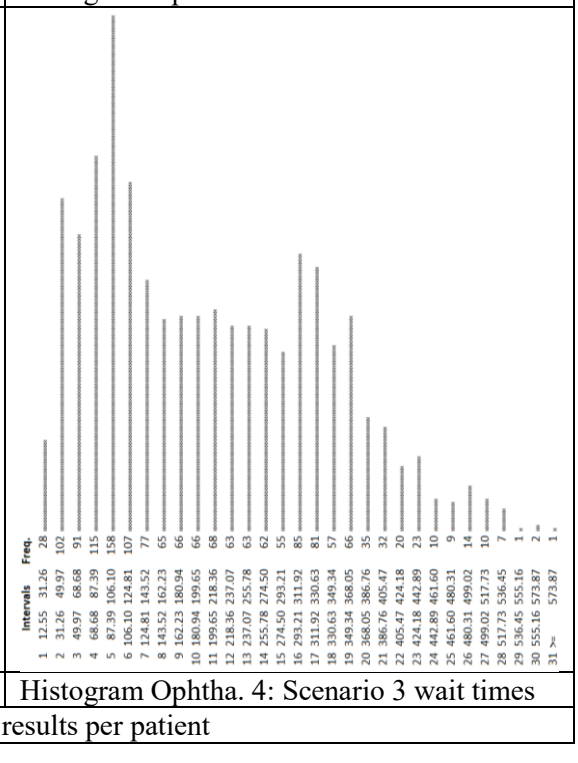
	Intervals	Freq.
1	0.32 15.14	147
2	15.14 29.96	133
3	29.96 44.78	142
4	44.78 59.60	92
5	59.60 74.42	100
6	74.42 89.24	72
7	89.24 104.07	40
8	104.07 118.89	60
9	118.89 133.71	55
10	133.71 148.53	59
11	148.53 163.35	50
12	163.35 178.17	48
13	178.17 192.99	43
14	192.99 207.81	61
15	207.81 222.63	42
16	222.63 237.45	36
17	237.45 252.27	43
18	252.27 267.09	71
19	267.09 281.91	45
20	281.91 296.73	58
21	296.73 311.55	47
22	311.55 326.37	51
23	326.37 341.19	47
24	341.19 356.01	30
25	356.01 370.83	29
26	370.83 385.65	14
27	385.65 400.47	9
28	400.47 415.29	6
29	415.29 430.11	5
30	430.11 444.93	4
31	>= 444.93	0

Histogram Ophtha. 2: Scenario 1 wait times



	Intervals	Freq.
1	12.20 32.03	34
2	32.03 51.86	105
3	51.86 71.69	85
4	71.69 91.52	131
5	91.52 111.35	157
6	111.35 131.18	112
7	131.18 151.01	80
8	151.01 170.84	70
9	170.84 190.67	81
10	190.67 210.50	67
11	210.50 230.33	68
12	230.33 250.16	62
13	250.16 269.99	58
14	269.99 289.82	75
15	289.82 309.65	75
16	309.65 329.48	82
17	329.48 349.31	70
18	349.31 369.14	55
19	369.14 388.97	56
20	388.97 408.80	31
21	408.80 428.63	18
22	428.63 448.46	19
23	448.46 468.29	9
24	468.29 488.11	7
25	488.11 507.94	16
26	507.94 527.77	8
27	527.77 547.60	6
28	547.60 567.43	1
29	567.43 587.26	0
30	587.26 607.09	1
31	>= 607.09	0

Histogram Ophtha. 3: Scenario 2 wait times

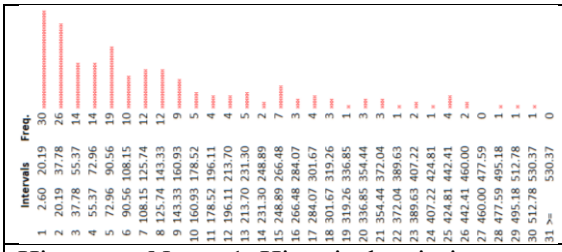


	Intervals	Freq.
1	12.55 31.26	28
2	31.26 49.97	102
3	49.97 68.68	91
4	68.68 87.39	115
5	87.39 106.10	158
6	106.10 124.81	107
7	124.81 143.52	77
8	143.52 162.23	65
9	162.23 180.94	66
10	180.94 199.65	66
11	199.65 218.36	68
12	218.36 237.07	63
13	237.07 255.78	63
14	255.78 274.50	62
15	274.50 293.21	55
16	293.21 311.92	85
17	311.92 330.63	81
18	330.63 349.34	57
19	349.34 368.05	66
20	368.05 386.76	35
21	386.76 405.47	32
22	405.47 424.18	20
23	424.18 442.89	23
24	442.89 461.60	10
25	461.60 480.31	9
26	480.31 499.02	14
27	499.02 517.73	10
28	517.73 536.45	7
29	536.45 555.16	1
30	555.16 573.87	2
31	>= 573.87	1

Histogram Ophtha. 4: Scenario 3 wait times

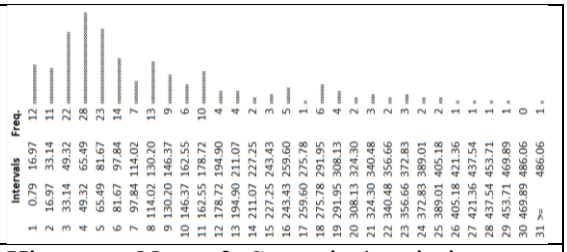
Histogram Ophtha. 0: Historical and scenarios results per patient

Appendix F5: Wait times Neuro-surgery



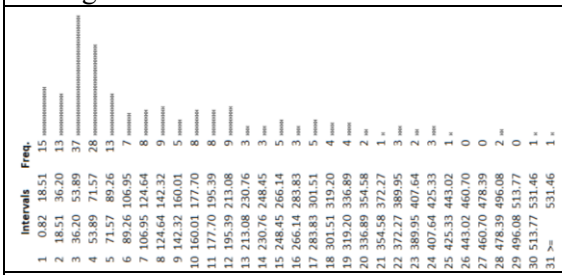
	Intervals	Freq.
1	2.60 20.19	30
2	20.19 37.78	26
3	37.78 55.37	14
4	55.37 72.96	14
5	72.96 90.56	19
6	90.56 108.15	10
7	108.15 125.74	12
8	125.74 143.33	12
9	143.33 160.93	9
10	160.93 178.52	5
11	178.52 196.11	4
12	196.11 213.70	4
13	213.70 231.30	5
14	231.30 248.89	2
15	248.89 266.48	7
16	266.48 284.07	3
17	284.07 301.67	4
18	301.67 319.26	3
19	319.26 336.85	1
20	336.85 354.44	3
21	354.44 372.04	3
22	372.04 389.63	1
23	389.63 407.22	2
24	407.22 424.81	1
25	424.81 442.41	4
26	442.41 460.00	2
27	460.00 477.59	0
28	477.59 495.18	1
29	495.18 512.78	1
30	512.78 530.37	1
31	>= 530.37	0

Histogram Neuro 1: Historical wait times



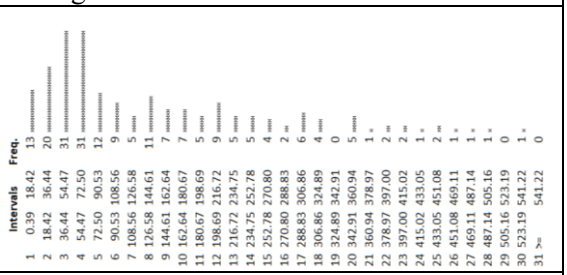
	Intervals	Freq.
1	0.79 16.97	12
2	16.97 33.14	11
3	33.14 49.32	22
4	49.32 65.49	28
5	65.49 81.67	23
6	81.67 97.84	14
7	97.84 114.02	7
8	114.02 130.20	13
9	130.20 146.37	9
10	146.37 162.55	6
11	162.55 178.72	10
12	178.72 194.90	4
13	194.90 211.07	4
14	211.07 227.25	2
15	227.25 243.43	3
16	243.43 259.60	5
17	259.60 275.78	1
18	275.78 291.95	6
19	291.95 308.13	4
20	308.13 324.30	2
21	324.30 340.48	3
22	340.48 356.66	2
23	356.66 372.83	3
24	372.83 389.01	2
25	389.01 405.18	2
26	405.18 421.36	1
27	421.36 437.54	1
28	437.54 453.71	1
29	453.71 469.89	1
30	469.89 486.06	0
31	>= 486.06	1

Histogram Neuro 2: Scenario 1 wait times



	Intervals	Freq.
1	0.82 18.51	15
2	18.51 36.20	13
3	36.20 53.89	37
4	53.89 71.57	28
5	71.57 89.26	13
6	89.26 106.95	7
7	106.95 124.64	8
8	124.64 142.32	9
9	142.32 160.01	5
10	160.01 177.70	8
11	177.70 195.39	8
12	195.39 213.08	9
13	213.08 230.76	3
14	230.76 248.45	3
15	248.45 266.14	5
16	266.14 283.83	3
17	283.83 301.51	5
18	301.51 319.20	4
19	319.20 336.89	4
20	336.89 354.58	2
21	354.58 372.27	1
22	372.27 389.95	3
23	389.95 407.64	2
24	407.64 425.33	3
25	425.33 443.02	1
26	443.02 460.70	0
27	460.70 478.39	0
28	478.39 496.08	2
29	496.08 513.77	0
30	513.77 531.46	1
31	>= 531.46	1

Histogram Neuro 3: Scenario 2 wait times



	Intervals	Freq.
1	0.39 18.42	13
2	18.42 36.44	20
3	36.44 54.47	31
4	54.47 72.50	31
5	72.50 90.53	12
6	90.53 108.56	9
7	108.56 126.58	5
8	126.58 144.61	11
9	144.61 162.64	7
10	162.64 180.67	7
11	180.67 198.69	5
12	198.69 216.72	9
13	216.72 234.75	5
14	234.75 252.78	5
15	252.78 270.80	4
16	270.80 288.83	2
17	288.83 306.86	6
18	306.86 324.89	4
19	324.89 342.91	0
20	342.91 360.94	5
21	360.94 378.97	1
22	378.97 397.00	2
23	397.00 415.02	2
24	415.02 433.05	1
25	433.05 451.08	2
26	451.08 469.11	1
27	469.11 487.14	1
28	487.14 505.16	1
29	505.16 523.19	0
30	523.19 541.22	1
31	>= 541.22	0

Histogram Neuro 4: Scenario 3 wait times

Histogram Neuro 0: Historical and scenarios results per patient