Patient flow through the central surgery unit at Haukeland Universitetssykehus

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A System Dynamic approch

By

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M.Phil Thesis

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Abstract

The Central operation division at Haukeland Universitets sykehus is considered to be the ”hart” of the hospital. At the same time surgery units are often singled out as an organizational unit that can constitute a bottleneck in the hospital and it is important to identify bottleneck leading to a sub-optimal flow through the unit. The main objective of this thesis is to investigate how the patient flow can be improved through a change in the structure underlying the problems at the Central operation division. The system dynamic method is employed and the study seeks, through modelling and simulation, to identify bottlenecks or problems that hinder a smooth and efficient patient flow at the surgery unit and identify and test structural modifications (policies) that may be implemented in the hospital.

Til Eirik

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A big Thank You to my supervisor Pål Davidsen for guiding me through my master study and inspiring me to go the "System Dynamic way".

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It has taken a long time to complete this thesis and I would not have been able to complet it if it had not been for the support from my husband, family and close friends.

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1 Introduction

For many years, hospitals in Norway have experienced problems complying with the need for medical treatment required by the population and, at the same time, remaining within the cost limits assigned. The population life expectancy has increased and caused a growth of the elderly population. Consequently, a “boom” of elderly is predicted in 2010 in Norway (Statistisk Sentalbyrå 2005, 16 mai). Moreover, medical research and improved technology has increased the opportunities for successful medical treatment and thus the number of patients eligible for such treatment. It stands to expect that this will lead to longer waiting lists. Currently, the waiting lists fluctuate within the different diagnoses and from one geographical region to another. To make sure that patients are treated within a reasonable time, the government has regulated these waiting times by law and introduced a free choice of hospital (Fritt sykehusvalg) (http://www.frittsykehusvalg.no/).

In the future, hospitals are expected to treat more patients per year then now. To be able to accomplish this, they have to treat patients more efficiently, given the current growth in demand for hospital care and the resources made available to hospitals. Increased efficiency is expected to improve patient throughput. In an effort to achieve better efficiency one may identify and remove various bottlenecks in the system. The government of Norway recognized the significance of bottlenecks in a parliamentary statement of 1995-96:

> “Flaskehalser i sykehus må kartlegges.
> Utredning og behandling av pasienter skjer ved et samarbeid mellom flere enheter i sykehuset, men kan forsinkes av flaskehalser som hindrer optimal ressursbruk. Operasjonsavdelingene kan representere slike flaskehalser fordi pasienter må strykes fra operasjonsprogrammet pga. hasteoperasjoner eller andre uforutsette forhold.” (St.meld. nr. 44, 1995-96)

In this statement, the surgery unit is being singled out as an organizational unit that can constitute a bottleneck because its resources are often in scarce demand and cancellations, say, often result from the need to conduct emergency surgery. Although the significance of bottlenecks and the need to identify them is underscored in the statement, calling for action, this remains an important issue in health organisations of today.

In this master thesis we address the patient flow through one division at the second largest hospital in Norway. The central surgery unit (Sentraloperasjonsavdelingen (SOP)) at Haukeland University Hospital is considered to be a critical component and it is important for the operation of the entire hospital that the flow of patient through this department runs smoothly and is served efficiently (Haukeland sykehus, 1998, b). The flow is dependent upon the resources available in the unit and resources acquired from other units located at the hospital. **The main objective of this thesis is to investigate how the patient flow can be improved through a change in the structure underlying this problem**. By employing the system dynamic method, this study seeks, through modelling and simulation, to identify bottlenecks that hinder a smooth and efficient patient flow at the surgery unit and to identify and test structural modifications (policies) that subsequently may be implemented in the hospital.

1.1 Project description

In this study we address a number of challenges faced by the central surgery unit, Sentraloperasjonsavdelingen (SOP), at Haukeland University Hospital. The study, conducted by the System Dynamics Group at the University of Bergen, has been financed in part through a research grant by Helse Vest.

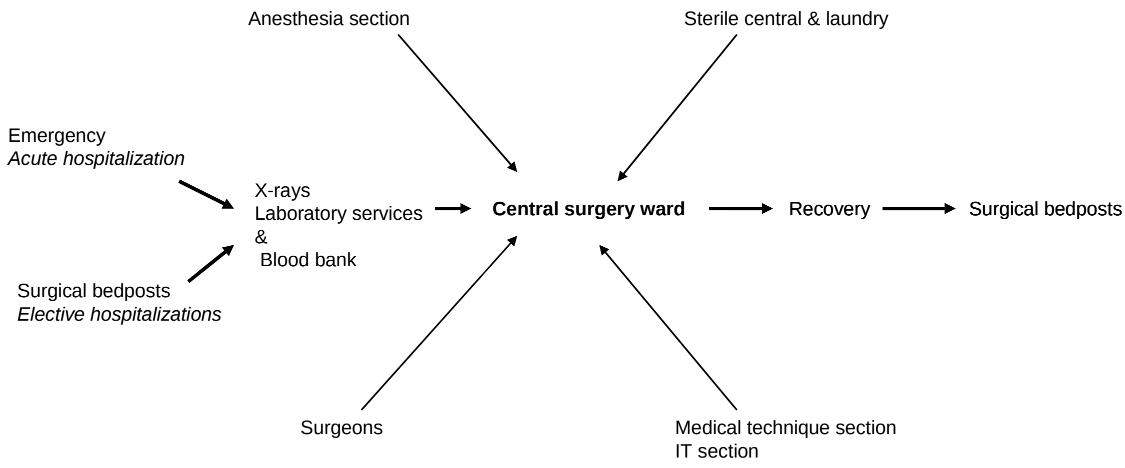


Figure 1: Surgical line with support functions (Fylkesrevisjonen i Hordaland, 2000)

Apart from minor operations, all surgical procedures at the hospital being are performed at SOP. The unit consists of four sections; Orthopaedic, General Surgery, Thorax and Head/Neck, and is operated by the surgery service clinic at Haukeland University Hospital (Kirurgisk Serviceklinikk (KSK)) (Haukeland sykehus, 1998 a and Helse Bergen, 2003 b). The surgery service clinic consists of several other sections among others the postoperative section, postoperative Thorax section and assistants and hospital orderlies. SOP produces annually about 10 000 surgical procedures and every second patient admitted at the surgery sections have a surgical procedure conducted at SOP (Haukeland sykehus, 1998, b). Every surgical section have its own pool of resources as well as its own budget and have been allocated specific surgery theatres at the ward. In SOP there are three locks through which the patients need to pass on their way in and out of SOP and an additional one through which patients pass on their way to the postoperative section. There are 22 operating theatres available of which about 16 are regularly in use, - depending on how the various medical disciplines utilize their capacity. A pre-operative preparation room is typically shared between two operating theatres. Associated with each theatre in regular use there is a surgical team consisting of one or more surgeons as well as an average of 2.3 surgical nurses and 1.5 anaesthesia nurses (one of two such nurses are shared between two theatres). There is also a supporting unit at the hospital that supplies hospital orderlies and helpers that perform a variety of auxiliary tasks at the SOP.

Following a reorganization, the surgery unit is now subdivided into the sections, Orthopaedic, General Surgery, Thorax and Head/Neck. The flow of patients through some of these sections is more well-regulated than through some of the others.

1.1.1 Problems at SOP

A main problem for Haukeland University Hospital is that SOP does not operate at a desired capacity and the utilization of SOP is considered suboptimal. It is hypothesized that bottlenecks and obstruction of a more general nature altogether give rise to this problem. A bottleneck is a system component operating at such a small capacity that it prevents the full capacity utilization of other parts. For instance all surgical patients must pass through one of only three locks on their way to the operation theatres. As a consequence of this limited capacity patients remain waiting for extended periods of time outside the SOP locks while the surgical teams inside SOP await the arrival of the next patient. This bottleneck has been claimed to cause delayed surgery start-ups and a suboptimal utilisation of resources. Obstructions of a more general nature may arise from prolonged procedures due to unexpected medical complications or the unavailability of special equipment or test results (x-rays, blood-analyses etc.), the use of temporary, less skilled surgical team members, resulting from unplanned sick leaves, or from cancellations in the surgery program for variety medical or organizational reasons.

It is important for the hospital to have the best possible through-put of patients to satisfy the ever increase in demand for treatment and to reduce the waiting list and waiting time for patients of various categories. The surgical procedure costs are supposed to be covered through a DRG system (http://www.shdir.no/kodeverk_og_pasientklassifiseri/drg/) and constitute a significant source of income to the hospital. But at the hospital the costs associated with surgeries are larger, on the average, than the compensations offered through the DRG system. An increase in the number of surgical procedures performed per day, will contribute to distribute the fixed expenditures across a larger number of procedures so as to reduce the cost per procedure. This will have the beneficial side effect that a higher number of patients are being treated per day and that the waiting times experienced by the patients are being reduced.

Because the various medical sections of the hospital have different resource requirements, including surgery theatres, the distribution of these resources and theatres are topics for discussion at SOP. Generally speaking, each section claims a larger resource requirement than they have at their disposal. Moreover, the various sections operate with different shares of emergency patients. It is commonly claimed that the costs per elective procedure is less than that per emergency procedure. This because elective procedures are better planned and, consequently, require less time and are, on the whole, more resource efficient than emergency procedures. Emergency patients arrive randomly and must typically undergo surgery within 24 hours and thus cause interruptions and inefficiencies in the elective program. This has medical as well as financial implications and complexes the situation because one cannot modify the number of emergency procedures and a reduction of planed procedures leads to an income loss and increased waiting lists. In spite of apparent inefficiencies, it is being claimed, that financial and medical gains can be made by shielding the elective treatment of patients from the emergencies by for example setting aside operating theatres dedicated to emergencies.

1.2 Research question

The purpose of this study is to use the System Dynamic method *to investigate the relationship between the SOP structure and its dynamics over time so as to identify the origin of inefficiencies that SOP may be facing as a result of a non-optimal utilization of resources associated with a non-optimal patient flow* and to develop and evaluate policies by which these challenges can be met. The performance of the SOP is measured in terms of patient flow and the resulting average fixed cost (i.e. utilization of resources) per surgical procedure.

The four surgical sections have all been included in the system dynamics model that constitutes our investigatory vehicle. Because all of the sections interact in their utilization of SOP, two sections have been described in detail and two merely in the form of their patient flow. Even though there are problems associated with every section at SOP the Orthopaedic section face the most serious challenges and will be the focus of this research.

1.2.1 Hypothesis and policies

The main hypothesis is that **bottlenecks in the system are reasons to a sub-optimal utilisation of resources leading to an inefficient patient flow.** This main hypothesis has been operationalized into the following hypotheses within various areas of the patient flow:

1. Delays caused by exogenous factors acting upon the system reduce the patient flow.
2. Improving the planning of the surgery program will increase the predictability of the program and, thereby, the patient flow
3. Exercising a certain flexibility regarding when dayshifts should end will prevent patient flow obstructions from early daytime de-escalation.
4. A good emergency patient flow is hindered by the lack of resources (personnel and operation theatres) at night.
5. A non-optimal patient flow is due to lack of personnel causing a bottleneck in the system.
6. Bottlenecks caused by lack of resources outside SOP constrains the patient flow through SOP
7. The lack of free locks constitutes a bottleneck that leads to a sub-optimal patient flow caused by a poor utilisation of resources.

Various policies are considered to test these hypotheses. They are aimed at falsifying or corroborating the hypotheses. The first hypothesis is tested through a policy decreasing delays caused by the late arrival of surgeons. By improving the program planning using experienced activity times one may test the second hypothesis. Hypothesis number three is tested by allowing different intervals of overtime for the personnel at SOP. The forth hypothesis is tested by way of several policies. The hypothesis claims that lack of resources at night, after normal working hour, is the reasons for an emergency flow and will be tested by adding a nightshift. To further test the hypothesis, two more policies will be examined; one having no elective surgeries one day a week and only offer surgery to emergency patients this day and the second having an added evening shift serving emergency patients only. The last two policies are tested to find out whether the resources shortages of significance only arise at nigh shifts or are also arising during the day or evening. The fifth hypothesis claims that personnel shortage causes a bottleneck in the system and will be tested by adding various personnel resources during the simulation. The impact of bottlenecks outside SOP on the patient flow will be exemplified and tested by adding more beds to the postoperative division. The last policy will be tested by changing the strategy for locking in patients in trying to free more locks at the time where they are most needed. (For more detail description of the policies and the hypothesis see chapter 5).

1.2.2 Key variables

Key attributes in this study are patients, resources and costs. The variables representing these attributes throughout the model we have developed are interrelated in the way that the patient flow is facilitated through (conditioned by) the allocation of resources that incur costs. The cost perspective is important when considering the realism of the policies proposed and evaluated. Policies leading to an increase in performance operations might also cause an unrealistic increase in costs hat would prevent the implementation of such policies. Researchers, like Wolstenholme, Groothuis, Van Merode and Arie Hasman, have underscored the importance of including costs in health care studies as it establishes a better foundation upon which policies may be compared (Wolstenholme, 1999) and (Groothuis, van Merode and Hasman, 2000).

1.2.3 The relevance of the study and research contribution

This thesis is a part of a larger research project aimed at studying the readjustment of the services in the health sector using system dynamic; model based simulation, analysis, policy design, and strategy development. The background for the project is the current and expected increase in public and private costs associated with the health service in Norway. There is expected to be a significant demand and potential for efficiency improvements in this sector. This implies that one need to increase the effectiveness of those means used to produce health care services, giving room for savings and, at the same time, increases the service quality. This is not and issue unique to Haukeland Sykehus and applies to hospitals all across the sector.

This research contribution of this thesis is an analysis of a significant portion of the "production line" of Haukeland Sykehus that in itself is considered a severe bottleneck. In particular, the challenges of planned and unplanned production interfering at this process point are addressed. With this thesis we intend to provide insight as to how these challenges can be met through policy design and strategy development and to assess the consequences that the hospital may be facing as a result of the policy changes suggested.

The system being studied contains bottlenecks with different degrees of influence which can be difficult to resolve and identify. Loosening one bottleneck and others can arise at other stages in the production line. Resolving bottlenecks can introduce new needs in order to get the best effect from the resolution. Many hospitals also struggle with the problematic issue of elective and acute flows, where unplanned patients interfere with the elective flow. The degree of interference varies depending on the degree the acute medical treatment occupy resources that otherwise would be used at elective treatment. Nationally and internationally, one has identified many challenges in the allocation of the acute and elective treatment. There has also been done much research in this field and several attempts to organise treatment of the two patient groups with both of the group's best interest in mind and at the same time gain a good resource utilisations. The increasing attention and distant of any conclusion indicates a complex theme and the challenge lies in attending to crossing considerations (Davidsen, 2005).

The interference of acute medical treatment in the elective treatment makes it necessary for the institution to face changes leading to a consideration whether it is an optimal strategy to isolate elective treatment from the interference. In reality, this strategy means putting away earmarked resources to certain stages - both medical and material resources. Effects of this can be that not all of the resources are utilized completely at all times. But a certain shielding of elective treatment can make parts of the organisation more efficient because it is planed leading to a bigger degree of accomplishment. The resource allocation demands many difficult balances which together forms a strategy for the business. The motioned issues are difficult to answer with out doing a study of the patient flow and this thesis research can lead to answers regarding the bottleneck problematic and give points as to what strategy is the best when looking at the acute vs. elective problem in the health care service (Davidsen, 2005).

The system dynamic approach has been used in several studies of health care problems- modelling amongst others patient flow. This study’s model includes a high level of details in order to reproduce the system being studied. System dynamic models focus on capturing the essence of the issue at hand and try to avoid modelling elements distant from the problem. In this study, the level of detail has been considered relevant because it reflects the many elements involved at SOP. A lower level of detail could have affected the correctness of the result. The study shows that system dynamic can be used as a method also in domains that involve many details, yet still capture the essence of the problem.

1.3 Organization of the thesis

The thesis will start by looking at empirical studies and describing the chosen method for this study. A description of the system dynamic model over SOP, its boundaries and the time horizon follows, before the different validation tests that have been performed are described. The results of the policy testing will then be presented. The theses will end with summing up the project.

2 Empirical studies and theoretical foundation

2.1 The importance of understanding patient flow

There has been an increasing interest in patient logistics with a focus on patient flow among health care providers. There are many reasons for this development, one being that increasing the flow of patients through hospitals is one of "the major elements in improving efficiency in the delivery of health care services" (Côte, 2000:1). This interest thus originates from cost issues and is accentuated by the fact that health institutions are financed on a refund basis where their payments are closely linked to the patient throughput. Côte states that a part of the motivation behind the need to understand patient flow has been brought about by a change in health care operations. In the United States most of the users of health care services paid, until the mid 1980s, health care providers on a cost reimbursement or negotiated cost reimbursement basis. The system left little incentive to concentrate on efficiency in delivering health care services, and the situation lead to a rapid increase in the cost of health care services. In the mid 1980s the federal government adopted a prospective payment system. Health care providers found themselves dealing with fixed payments for their services and they could no longer pass their cost on to the payers. These consequences created a real incentive for health care providers to concentrate upon efficiency in the delivery of health care services and began to pay attention to patient flow at their facilities, to understand and manage that flow better (Côte, 2000).

There has been a similar development in Norway where an ISF (Innsatsstyrt finansiering) system has been adopted. The system builds on DRG- system where expenses associated with the treatment of patients at public hospitals is refunded according to the, so called, Diagnose Related Group (DRG) rates (http:// www.shdir.no/ kodeverk_og_ pasientklassifiseri/drg/). ISF is a financing system directed towards the regional health enterprises. Through the financing system parts of the budget to the regional enterprises are dependant on the amount of patients getting treatment. Through the ISF system the government undertake a partly responsibility for cost with more patient treatments then planed. This risk-sharing help for the regional health enterprises to activity finance underling health enterprises. The activity financing is suppose to stimulate a better charting of costs and identification and removal of bottlenecks hindering an efficient patient treatment. Without this system it would be “cost free” to reduce the patient treatment because the regional health enterprises would not lose income. (St.prp. nr. 1, 2006–2007). Lately, hospitals have paid even more attention to the significance of managing the patient flow well as a mean to meet the budget, treat more patients to reduce waiting list, and, this way, keep patients from choosing a treatment at an alternative hospital.

In order to relieve pressure on the health care service and to improve the interaction between the health care sectors, one needs to consider the entire patient flow leading up to and away from institutionalization. This calls for “whole system thinking” (Wolstenholme, 1999). That would allow for coordination of the policies governing resource allocation across the various stages of the patient flow process and thus a strategy for the management of the patient flow across the various sectors of health care services. An understanding of the patient flow can also offer insight to health care providers so that they recognize themselves as parts of this larger system (Côté, 2000). Another important point in understanding patient flow is the LEON (Laveste Effektive Omsorgsnivå) principle of Lowest Effective Service Level (LESL). In the Norwegian health care this principle states that a patient must be treated within the right time and at the correct professional level. The principle includes that one should not use more recourses on a health problem then what it takes to address any heath issue at hand effectively, in time and as justifiably close to the patient as possible. There are many reasons why health care providers may find it difficult to follow the LEON principle in the face of issues such as an increasing number of acute patients, unacceptably long waiting list for elective patients and ward overload that causes patients to be inappropriately located and subsequently relocated causing resources to be ineffectively spent and that delays appropriate treatment of patients in need.

2.2 Strengths of simulation model techniques

Many methods exists that may support health care services in their decision making process and successful application of these tools requires an understanding of the structure underlying health care provision, such as the patient flow and the policies governing that flow (Côte, 2000). The appropriateness of any method, technique or tool depends on the research question or the problem at hand. The methods applied often include modelling and simulation, because of the complexity of the underlying structure.

Modelling and simulation techniques are applied “in the context of real world problem solving, with all its messiness, ambiguity, time pressure, politics, and interpersonal conflict. The purpose is to solve a problem, not only to gain insight” (Sterman, 2000:83). A key strength of simulation is the ability to model the behaviour of a system as it develops over time (Ball, 1996) and the opportunity that offers to identify the root cause of a problem, i.e. the underlying structure generating the behaviour that has been identified as a problem, and to solve a problem by way of changing that underlying policy.

People base problem solving on their mental models that often are simplified representations of the real world. Consequently, to avoid over-simplification, there is a tendency to specialize; - to develop profound insight into a specific sector, and to remain ignorant about the issues beyond. When required to make inferences that involves other sectors, the mental models do not hold sufficient quality and typically, say omits feedback and underestimate time delays of great significance to the systems performance (Sterman, 2000). Moreover, even if our mental models of the underlying systems structure is of sufficient quality, our ability to infer the consequent behaviour is severely limited by our mental capacity. As a result, the policy evaluation that we offer may not hold an acceptable quality and our recommendations may not be valid. Policies that are expected to have a certain impact may have none or, even worse, the opposite effect. And policies that actually do have an effect are often ignored. In our attempt to remedy these capacity limitations, we may make extensive use of modelling and simulation. That way we may build our policy conclusions on a set of assumptions that realistically represent the complexity characterizing real systems structures and derive appropriately the consequent behaviour

To overcome the limitations of our mental models simulation models can be built to increase the understanding of the system and problems within a system. Results of simulation runs and seeing the behaviour evolve over time can increase the way one understand the system and in this matter make it easier for health care providers to understand problems they encounter and help them make better decisions. Models and simulation is also a good way to illustrate changes visually and the effects resulting from a system change. Evidently simulation models can be used to detect the rise of problems and explain why they occur (Sterman, 2000).

We may offer a variety of structural solutions to a problem and it is not always evident which will provide the best results. Using modelling and simulation, we may design and test policies (decision processes). This is important because, solutions that intuitively seem reasonable may not result in any significant improvements and vice versa. This is especially important in health care enterprises in which policy modifications whether positive or negative, may seriously affect the health condition for the patients. Moreover, testing out policies this way is remarkably less expensive than implementing for real them on a trial basis, - and it is practically risk free (Wolsenholme, 1999).

Finally, modelling and simulation techniques also allows for the identification of optimal policies prior to their implementation. There are several different approaches that can be used building simulation models. It is difficult to conclude which method that is the best and they can in some instances complement each other. I will not try to conclude this discussion here but rather described shortly the method used in this study and explain why this method was chosen before other methods or techniques.

2.2.1 System dynamic

System dynamics (SD) can be defined as the study of complex, dynamic systems, the analysis of the relationship between structure and behaviour in such systems, and the design of policies that govern decision making and that make up a managerial strategy. Complexity manifests itself in accumulation processes that altogether constitute delays, feedback and non-linearity. SD is concerned with the behaviour of complex systems and is therefore grounded in the theory of nonlinear dynamics and feedback control developed in mathematics, physics, and engineering (Sterman, 2000). Sterman emphasizes that “System dynamics is a method to enhance learning in complex systems" (Sterman, 2000:4). Much of system dynamics modelling is "…discovering and representing the feedback processes which along with stock and flow structures, time delays and nonlinearities, determine the dynamics of a system" (Sterman, 2000:12). Using the method, we consider the state of a system modelled as the levels taken by a variety of stocks, each representing an accumulation of corresponding in- and outflows. The substance that is subject to such accumulations may vary from model to model as well as within models, from tangibles (such as material) to intangibles (such as a perception or an opinion). Each such accumulation constitutes a delay in the system in that a stock level does not change momentarily in response to a change in a flow rate. Time must pass for the stock level to change. Thus each of the flow (rate) stock (level) transitions constitutes a delay.

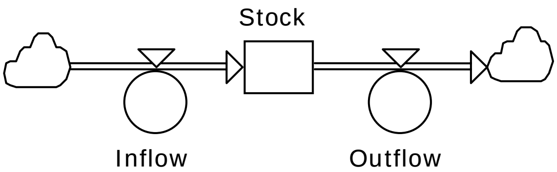
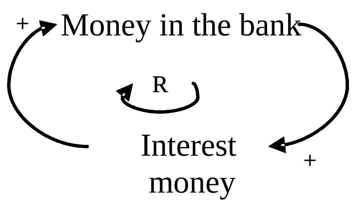
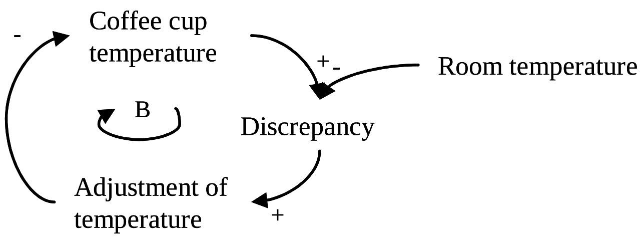


Figure 2: Graphical stock and flow notation

Moreover, in system dynamics we consider two types of feedback loops; reinforcing and balancing loops. The reinforcing loops amplify the dynamics of a system , much like the interest on a deposit in a bank account which, left in place, will increase exponentially; the more you have the more you get, - the more you get the more you have next time around. The balancing loops counteract the dynamics of the system and lead the system towards a goal (that is implicitly or explicitly stated). The typical example of a system with an implicit goal is a coffee cup in a room. The coffee temperature will adjust to and remain at the room temperature (the implicit goal). A complex, dynamic system typically consists of many reinforcing and balancing loops of various strengths that change over time, - where the loops interact non-linearly in creating the behaviour of the system.





In the system dynamic approach problem solving is looked at in a different way than what people usually do. People often try to solve problems with an event-oriented way of thinking - thinking that every cause has an effect and solve problems by looking at the situation, comparing it to our goal, and make decision on this basis. One hardly think that the system may react to the solution in a way which makes yesterday's solution today's problem, due to regarding ones standing from the outside of the system and not as a part of the system as a whole. Other issues that are easily ignored are feedback. Feedbacks in the system responds to changes resulting from decisions or policies inflicted on to the system - "The result of our actions define the situations we face in the future" (Sterman, 2000). Not considering the feedback makes it hard to predict the best policy and the future effect that it can have on the system. Effects can also be delayed making it even harder to predict the result. The System Dynamics method gives the opportunity to see the effects of a change in the system before the change has been implemented in the real system. Feedback, delays and non-linearity becomes visible, through models and simulation results, and gives a unique chance to consider whether the effect is good enough to actually be implemented into the real system.

The system dynamic approach is one way to study patient flow, resources utilisation and consequences of making changes. An example is the study on the development of national policy guidelines for the U.K. health services with a model over the total patient flow through the U.K. National Health Service. The goal of the study was to test "alternative major new structural initiatives for relieving pressure on health services and to complement health initiatives in " joint working" at the interface between health care sectors" (Wolstenholme, 1999:253). In the paper documenting this study, the authors discusses the application of a systems dynamics flow perspective on health service across primary, secondary and community health care provision. This is done so as to broaden our thinking about "alternative high-leverage interventions, not only to relieve temporary imbalances, but also to indicate the relevance of alternative interventions on a regular basis" (Wolstenholme, 1999). In the study the focus of concern was the growing waiting lists for elective surgery and the increasing rate of non-elective hospital admissions, - both of which may be considered resource allocation problems and leads to an increase in length of hospital stay and reduced hospital discharges. The study consisted of a simulation model of patient flow through the primary-and secondary health care and the community care. Two versions of the patient flow model where created to cover a wide range of possible situations that could occur. One model represented a situation with a high percentage of patients moving from hospital care to the community care. The other model represents the opposite situation with a low percentage of patients transferred to community care. Both models went through the same policy tests. Results from these tests showed that a reduction in the length of stay and intermediate care has a more significant impact on the total number of people waiting than a change in the hospital bed capacities. When additional bed capacity was introduced, more people may be admitted to the hospitals. However, the effect was temporary and as soon as the new capacity was fully utilized, the number of patients in the hospitals stabilises and the pre-hospital waiting time rise again (Wolstenholme, 1999). Wolstenholme states that a learning point from system dynamics simulations is that it allows organisations to perform risk-free testing of the magnitude of consequences over time of change management. In the case of the motioned study, testing of the policies showed the behavioural effects of the policies and, in this matter, provide insight into the system which can be used in the decision-making process (Wolstenholme, 1999).

System dynamics is demonstrating itself, in a number of industries, to be an important framework for improving understanding of complex organisations. Its use of “models as learning”, involving descriptions of organisations in terms of aggregate processes, policies, organisational boundaries, information links and delays, can lead to improved communication and changing of mental models and ultimately to brake down barriers involving culture, attitudes and beliefs (Wolstenholme, 1999).

2.3 Method of investigation

The system associated with the problem considered in this study is complex. It is difficult to comprehend all of the interactions and effects key variables have on each other without using some form of model. Moreover, there is also a variety of stakeholders involved, such as the employees at SOP, the users of SOP, and the owner of SOP (KSK), - each with their own agenda. Stakeholders have different understandings of how the system works, typically coloured by their different perspectives. The employees, for example, face the challenge of an increase in acute patients that causes cancellations and increased pressure to work overtime – leading to the assumption that they are understaffed. Because of alterations and cancellations of operations, users of SOP, such as divisions surgeons, may get the impression of inefficiencies in the utilization of resources, - arising from the resulting uncertainty as to when it is time for the surgeon to arrive at SOP. Increased waiting time for acute patients and cancellations imply longer stays for the patient, and overtime spent to deal with this matter implies increased costs to the owner. Inefficiencies in resource utilization and cost overruns troubles the board. So the same systems problems may give rise to a number of different concerns, agendas and proposals for solutions, depending on the perspective chosen Appropriate methods, techniques and tools are required to bring these perspectives together in a comprehensive, coherent and consistent representation of the system that can form the basis for analysis and problem solving. In lack of analytical tools to address systems of this complexity, simulation techniques are required to derive the behavioural consequences (the development) of the system structure, including modification in that structure, so as to allow us to understand the nature of the problem we are facing and to search for an optimal, comprehensive solution to that problem.

In this thesis, we have preferred to employ system dynamics as our method of investigation. This is because the method supports modelling across various perspectives and disciplines, offers an explicit representation of the stocks and flows of patients of various categories in and between stages of treatment, and of the resources at the disposal of SOP and their use. The accumulation processes represented in the model allows for capturing the delays that typically arise in these systems and provides and accurate account of the nature of these delays, - their underlying causes. Non-linear relationships are prevailing and cause the system to respond to externalities and managerial actions in ways that are conditioned by the current state of affairs, - say current level of resource utilization. System dynamics allows for an explicit representation of these non-linearities in the underlying systems structure and to derive, through simulation, their behavioural consequences that are often unexpected. Non-linearities cause the influence of various sub-components of the system to synergize, so that their effects are mutually interdependent and that the effects of modifying one, depends of the state of affairs in other parts of the system. This is true, say, if the resources of one kind made available to SOP is not matched by the availability of other kinds of resources. Providing resources of one kind does not in itself allow for the execution of a process that it takes a variety of resources to complete. System dynamics also allows for the explicit representation of the uncertainty associated with externalities to which the system is exposed, such as the arrival of time and nature of emergency patient arrivals.

There is a variety of other modelling and simulation techniques and tools available, each constituting a particular systems perspective. In hospital modelling and simulation, Discrete Event approaches (Groothuis, van Merode, Hasman, 2000) as well as Agent Based techniques (Borshchev and Filippov, 2004), (Narzisi, Mysore and Mishra, 2006) first and foremost come to mind. When we have chosen not to employ a pure discrete event simulation, rather support a hybrid perspective, it is because the discrete events, such as the employment or release of a resource or changes in a queue (Schruben, 2000), result from a synthesis of continuous development that we have chosen to represent explicitly in our model and are not predefined. System dynamics allows for the simulation of discrete event in response to such a continuous development.

Agent based models work for the most part discretely both in time and space (Borshchev and Filippov, 2004). Aside from discrete time, discussed above, one may consider SOP as a system that operates discretely in space. The personnel and patients may be considered as agents responding in accordance with their internal dynamics to externalities, i.e. in interactions with other agents. When we have chosen not to employ agent based modelling, rather employ a hybrid perspective, it is because these agents in many cases may be considered effectively from an aggregate perspective. These aggregates are exposed to continuous inflows and outflow. To the extent called for, system dynamics allows for the modelling of individual agents, such as patient, their individual characteristics and their idiosyncratic dynamics.

This thesis has been based on the steps of the modeling process described by Sterman (Sterman, 2000). The problems addressed in this thesis are a reflection of the concerns raised by the hospital at the initiation of this project. A system dynamics model was developed to portray the underlying systems structure responsible for the problems that had been identified. Moreover, a sequence of policies were developed, combined and tested by way of simulations. The finding resulting from one set of simulations provided the point of departure for additional policy design and testing. In general, each policy was intended to remove bottle necks that constraints the patient flow. Thus we employed the Steepest Ascent method in the design and testing policy as a way to search for and identify optimal combinations of interventions. The method is one of the oldest and most widely known methods for solving optimization problems (Quiroz, Quispe and Oliveira, 2006). See also; (http://www.physics.utah.edu/~detar/phycs6720/handouts/curve_fit/curve_fit/node5.html).

3 The system dynamic model of SOP

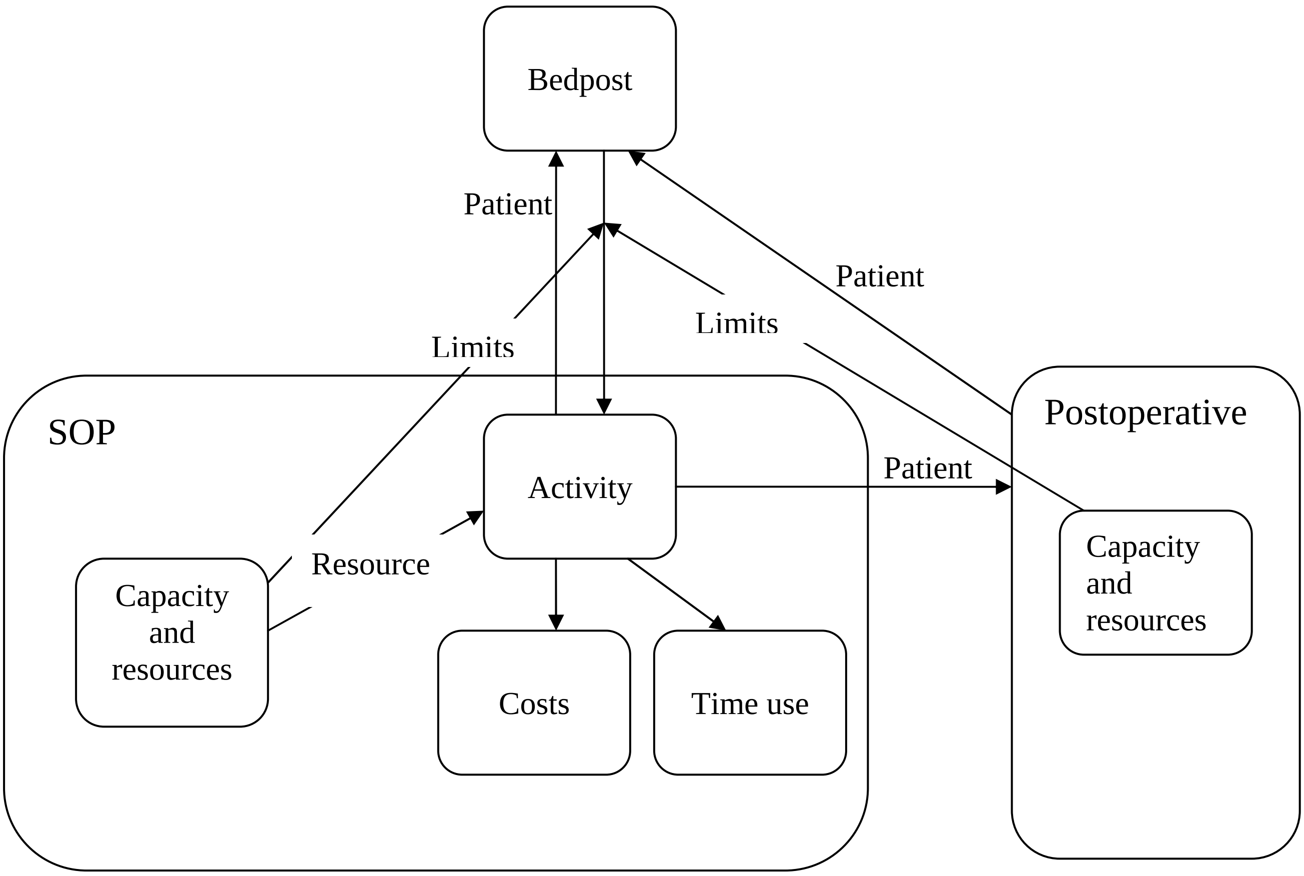
The structure of this thesis models configuration will here be described together with the model boundary and the problems and solutions faced in the modelling process. The chapter is divided into different parts where the first part describes the model boundary and time horizon. The second part consist of the model description, where some parts of the model are described in detail while others are seen as average system dynamic knowledge and are not thoroughly explained. The calculation of the different variables used in the model and the assumptions and problems faced in the modelling process will also be explained. The chapter ends with how data and information was gathered.

3.1 Model boundary and time horizon

The System dynamic method includes a variety of tools like, sub model and boundary chart, to communicate the model boundary and too represent the models casual structure. To capture every element regarding the problem statement the boundary has been set to include the patient flow from the bedpost, through SOP and the postoperative division as showed in the sub model illustration. The boundary has been set wide enough to include all aspects that have impact on the flow of patients.

3.1.1 Model boundary

The sub model shows the models boundary and elements included in the model. Elements outside the SOP and postoperative frame are modelled in lesser detail then rest of the model. The bedpost in the model is modelled as a collection place for patients waiting to be operated resources and other constraints at these posts are not included. Patient arrival at SOP triggers activities that need to be performed. Resources are needed to carry out activities leading to accumulation of cost and time. After completion of the activities the patient leaves the SOP frame to the postoperative division or returns to the bedpost. The capacity at SOP includes infrastructure like operation theatres and resources like personnel, at the postoperative division the capacity consist of beds and resources. The number of beds at the postoperative division and capacity at SOP can limit the flow of patients.



The model boundary chart contains key variables and summarizes the models scope. The table below illustrates the most important variables and shows which are endogenous (arising from within), exogenous (arising from without) and which are excluded from the model.

Endogenous	**Exogenous**	**Excluded**
Patients	Cost pr unit	Salary or cost pr unit raise
Operation type	Hours of work	Activities which does not included patients
Resources	Amount of operation types	Soft variables
Time delays		Equipment
Cost		Patient information
Activities		
Canceled operations		
Resource utilization		

Table 1: Endogenous and exogenous variables

The most important variables are endogenous – used when explaining the behaviour of the model. Endogenous variables are also vital to solving the problem statement. The exogenous variables do not produce any important feedback in the model and are exogenous because they are not considered to change much within the time horizon. Some of the exogenous variables might be used in testing different policies but again there will not be any feedback to these variables and they will not change during the time horizon.

Excluded variables are among other *increase in cost pr unit* or *raise in salary* for the personnel. The unit costs are collected from the budget and any increase in prices or salary should be taken into account in the budget leading to a fixed unit cost though out the year. Personnel activities are in the model restricted to activities that considers the patient flow. Other activities like courses and lectures are not included. Activities that do not include patients like lunch, cleaning of equipment and administrative work are included in the model because these elements occur on a daily basis and can influence the patient flow by making resources unavailable to perform activities. The personnel are divided into different groups according to their profession but other information like experience, stress, working environments are not considered. The competence element is the most important element of those left out. In this thesis it would be too big of a task to survey the level of personnel skill and competence. The hospital is also a university hospital and they have an obligation to teach and train inexperienced personnel and there will therefore always be different levels of skills among the personnel. Stress-level is also a variable that is not considered. The stress-level can impact the patient flow, but is not considered in this project because it would lead to a bigger study and a need for more interviews.

Lack of concrete data about the equipment made it impossible to include in the model. The model does consider that personnel uses time to clean and tidy the equipment, making the personnel unavailable to perform other tasks.

Information about the patient is constrained to consider the operation type and whether the patient is elective or acute. Elements like age, sex or complexity of the patient's diagnosis is not considered because they can not be changed through policies and will always be a part of the patient treatment. Some of the information is also very sensitive and can not be given to persons outside the hospital. These patient elements have also not been mentioned in any of the interviews or reports as an important problem which is the main reason as to why they are not considered.

3.1.2 Time horizon

The time horizon is set to one year. Sterman states that “the time horizon should extend far enough back in history to show the problem emerged and describe the symptoms” (Sterman 2000). In this case that is difficult because structural changes have been made at SOP over time. The different problems may also always have been a part if the system but hidden only to surface after an increase of pressure on the system caused by more patients needed to be operated. After talking with the hospital they agreed that one year could well illustrate their problem. The time horizon “should also extend far enough into the future to capture delayed and indirect effect of potential policies” (Sterman 2000). The different delays in the model are small and will therefore be captured within a one year time span. The time horizon will also capture effects of policies because of the small length of the delays. Although, it will be considered to expand the time horizon if a policy does not have the thought effect within one year to make sure that the time horizons length is not the reason for the lack of effect.

3.2 Model description

The model in this thesis is built up around the patient flow through four sections at SOP. Two sections, the Orthopaedic and Thorax section, are modelled with resources, cost and time use. The patients flows connected to the two less detailed sections where included because they can have an impact on the patient flow of the other sections. The Orthopaedic section is the main section in this thesis, chosen because the hospital considers it to be most problematic due to the increase in immediate care patients. As a counterpart the Thorax section was chosen. It has an equal number of operation theatres as OT and almost the same amount of resources but it does not have the same problems as OT. Having two sections can utterly confirm a policy if it gives good results at both sections or chart the consequences a policy at one section can have at other sections. In addition to the model I made an interface over the patient flow, the cost and time accumulation spent at the different activities. The interface has been used to increase the understanding of the model to people not familiar with the modelling of system dynamic models.

The model structure consists of several connected model parts that interact with each other. The patient flow structure of the model is illustrated in the figure below.

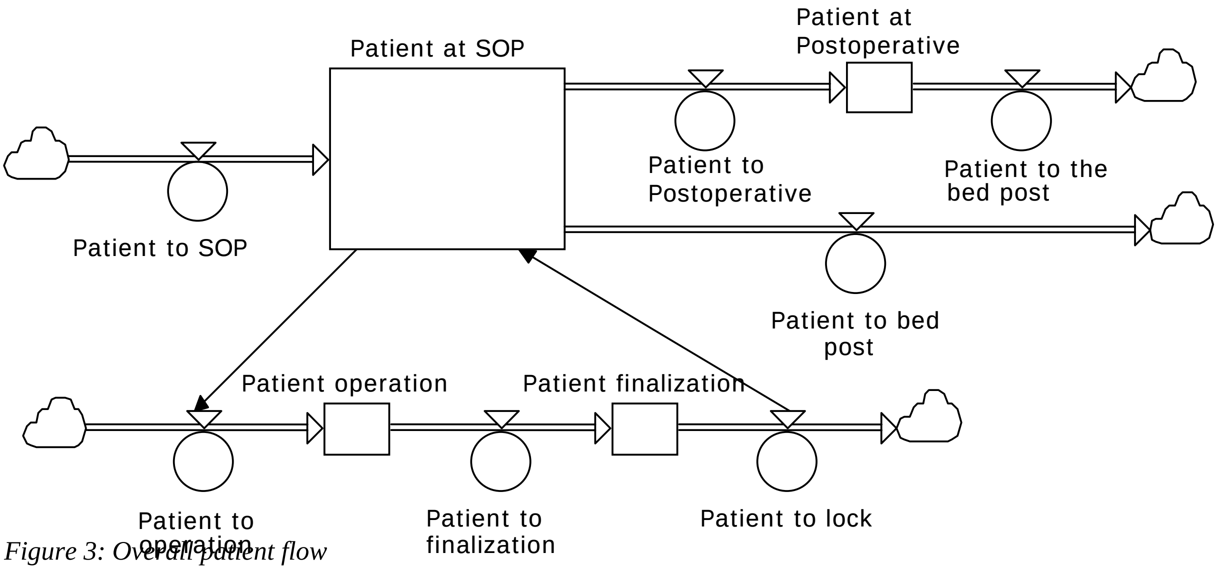


Figure 3: Overall patient flow

Patients that arrive at SOP, goes through several activities at SOP and then flows to the postoperative division or straight to the bedpost. A co-flow to the patient flow keeps track of patient information (operation type) as the patient flows through the system. Each of the different operations, within a section, has been given a unique number which indicates the operation type. The information in the co-flow decides the amount of time the personnel is to use performing their tasks at the different activities (see figure 4). The time needed performing the different activities vary after the operation type. The information flow is also necessary to keep track of which operation that has been performed and to connect the right cost to the correct operation type.

The model also contains a co-flow carrying a range number. The co-flow was made so that the model could run the operation program as it occurred in 2004. The range numbers are linked to the operation program that was performed in 2004 and are to be used in the validation of the model. The range number is used to get the patients position in the operation program performed in 2004 together with the date the operation was performed, the patient's operation type, the operation theatre number and the different times the patient spent at different activities.

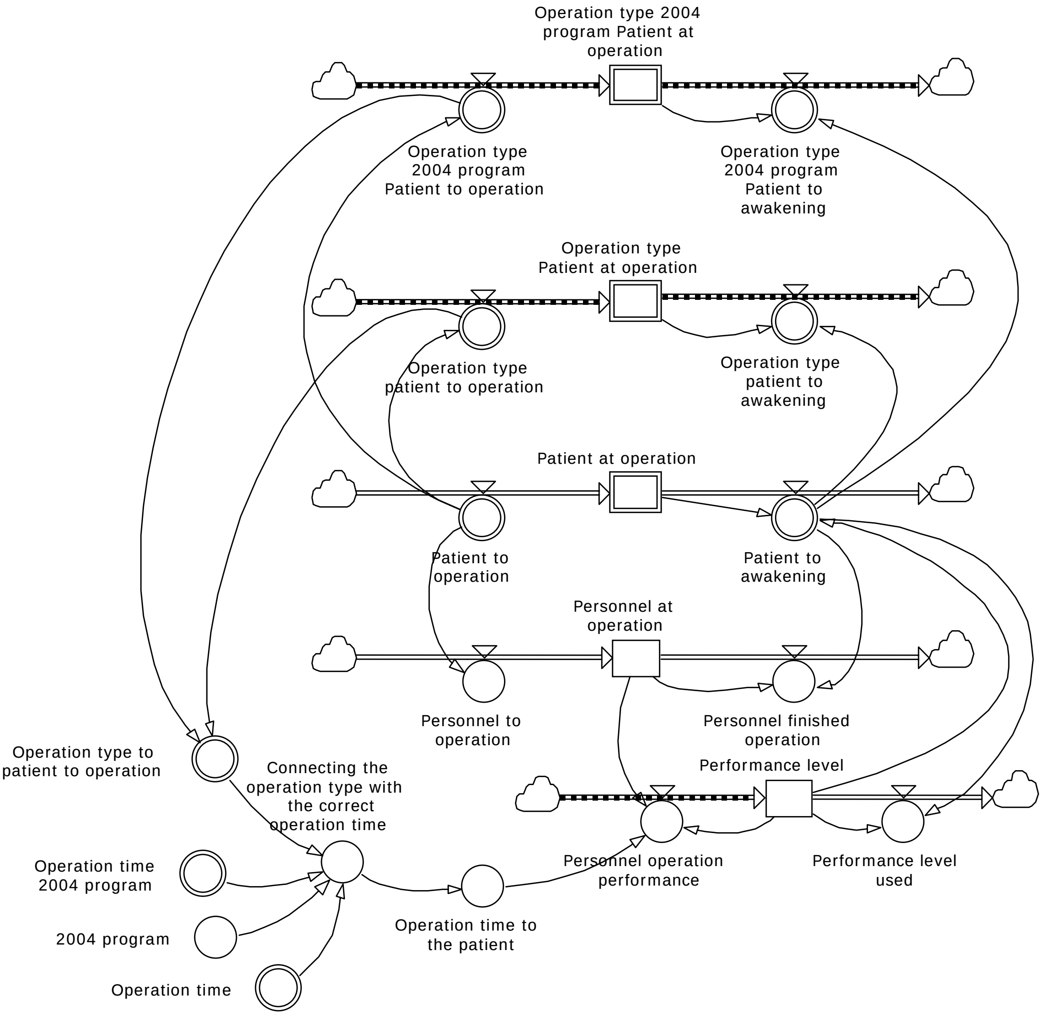


Figure 4: Illustration of the model construction of how the co-flows are connected to the patient flow.

<u>*Operation type to patient to operation:*</u> IF(2004 program>0;'Operation type 2004 program Patient to operation; 'Operation type patient to operation)

<u>*Connecting the operation type with the correct operation time*</u>: IF('Operation type to patient to operation'<>0 AND 2004 program=0;'Operation time'[INDEX('Operation type to patient to operation')]; IF(2004 program>0 AND 'Operation type to patient to operation '<>0;'Operation time 2004 program [INDEX('Operation type to patient to operation')];0<<min>>))

The personnel perform the different activities triggered by arrival of a patient at SOP or by a patient flowing to the next activity. When all of the personnel groups are finished with their tasks connected to an activity, meaning the performance level has reached the value of one (100%) the patient can flow to the next activity.

Cost is at each activity accumulated and connected both to the activity and to the patient's operation type making it possible to identify what the different operations cots. The time use is also calculated to see how much time the personnel use on the different operations including different delays.

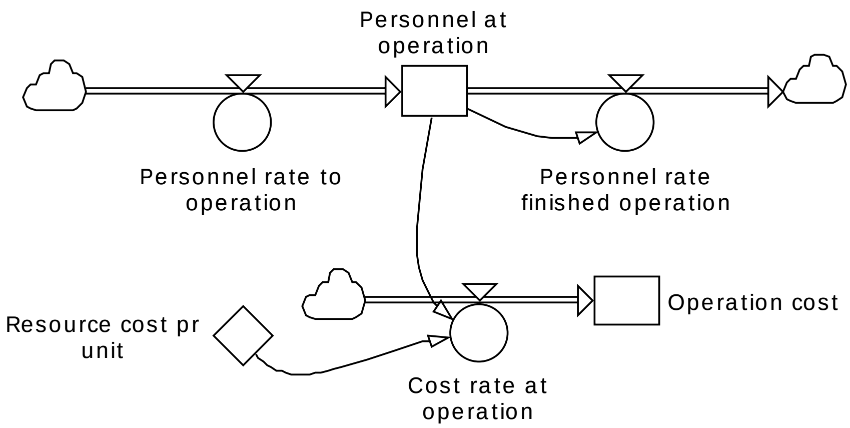


Figure 5: Accumulation of cost connected to an operation.

To make the model more reliable and recognisable I have, when naming the different elements, used names that are equal to those being used by the personnel at the hospital. This has been a help when presenting the model and during interviews. Speaking the same language has made it easier to avoid misapprehension. Neslon Repenning underlines the importance of having the right labels in a model: "Since its earliest articulations, good system dynamics practice has emphasized operational representation and the value of choosing variable names that closely correspond to the labels used by the client of the modelling effort." (Forrester 1961 and Sterman 2000 in Repenning, 2003:305). In his work he realised that the names of elements in his models was vital when trying to explain the model to others. Not doing this can lead to misunderstanding and that people draw lines to other models that are similar and not discovering the uniqueness of the model (Repenning, 2003). By using the same names as employees in the hospital it has been easier for me to remove mistakes in the model. The personnel have also easily been able to point out elements that have been wrong by recognising the variables names in the model structure.

Some of the flow elements in the model are discrete variables or agents. Patients are modelled as discrete variables due to the information flow connecting one operation type with one patient. The personnel variables are also discrete because of the level of detail in the model a continuous flow of elements could lead to a smoother patient flow. A patient could then faster arrive at SOP and half a resource cold start on the patient treatment. To also be able to keep track of the different patients they have been modelled as discrete elements as the resource elements - responding to changes in the system based on their need to perform different activities.

3.2.1 Model description in more detail – patient flow

The patient flow in the model is made out of several activities, one followed by another, bringing the patient from the bedpost through an operation and back to the starting point. The first step is the pre-preparation indicating the patient next in line to be operated. When the pre-preparation is completed by the personnel, and it is clear for the next patient at SOP, the patient is taken from the bed post to SOP. Arriving at SOP the patient needs to be locked in through a lock. There are three locks and only one patient can be in the lock at the same time leading to queues of patients outside the locks. After going through the locking activity the patient gets prepared for the operation. The preparation starts in the pre-preparation room and is finished in the operation theatre where the operation takes place. The operation is followed by the finalization activity which often includes awakening of the patient from the anaesthesia. The patients are at the operation room when the finalization occurs but the activity is modelled separately because it involves other resources then the operation. The patients then goes through another locking process either through the same locks that lead to SOP or through the lock to the postoperative unit. There is only one lock to this unit which might result in queues. The patient gets a bed at the division and spends some time there before returning to the bed post.

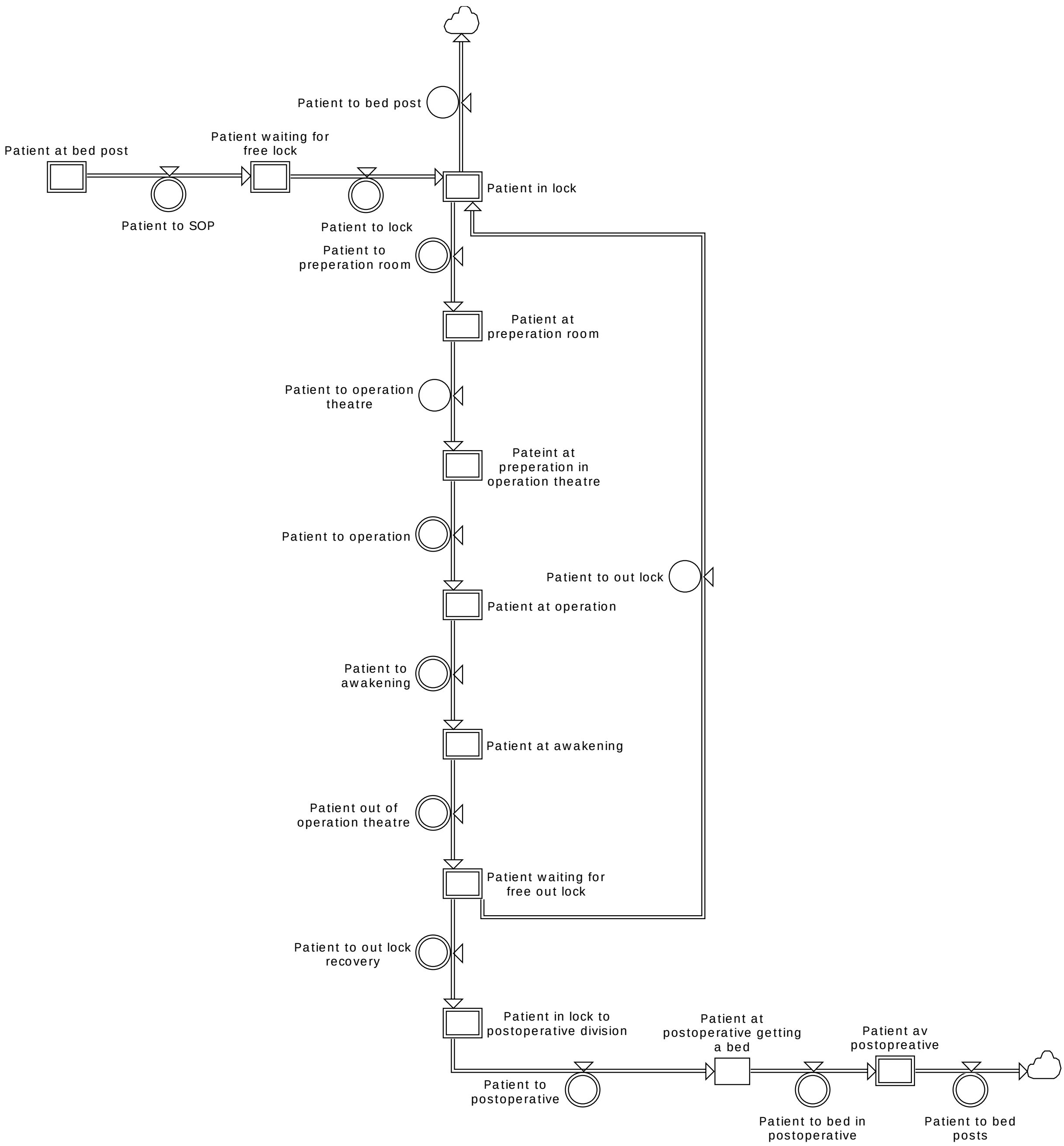


Figure 6: Model over the patient flow at SOP

The patient flow connected to the OT and Thorax section is modelled so that the performance level for the different personnel groups, at the different activities, have to be completed before the patient can go to the next step (see figure 4). For General Surgery and Head/Neck the patient flow is constrained by time delays indicating how long the patient is to stay at the specific activity. The length of the delays is determined by the operation type of the patient.

The patient flow consists of an array structure and each operation theatre has its own patient flow. This makes sure that the right patient gets operated at the right theatre and that the right patient information follows the same patient throughout the flow. The range names are the names of the different operation theatre that the sections have been assigned.

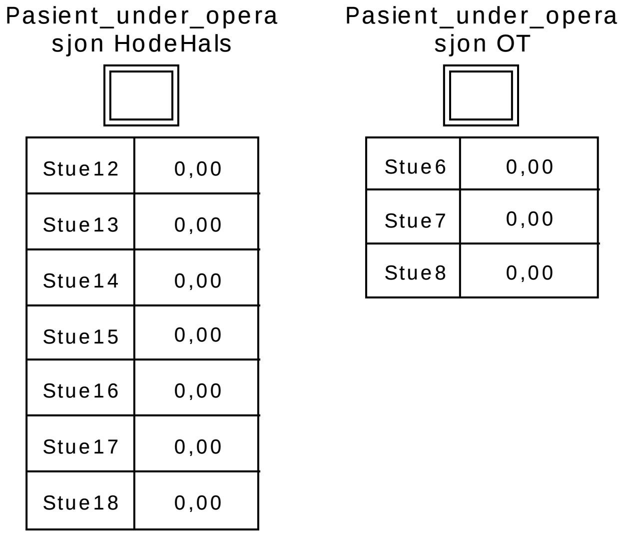


Figure 7: Array structure of the patient flow with operation room names as ranges.

3.2.1.1 Modelling of the operation program and the immediate care queue

<u>Planed operation program</u>

The patients in the model are either elective or acute patients. Admitting elective patients to the hospital is controlled by the surgeons who plan the operation program. The operation program is made for each of the different operation theatres that perform elective operations. In the model the operation program is constructed before the first shift starts. To make sure that the operation program will be as equal as possible between simulation runs a smaller model has been used to pick out operation types and construct a list of operations and the order of the operations that is to be operated at the different operation theatres. At the beginning of each simulation the list is placed in a stock “Remaining operations in list”. As an operation is placed in the operation program it flows out of the list (see figure 8).

The operation program (see figure 8) can not exceed the length of the day shift, meaning one working day (7, 5 hr). To estimate the length of the operation program the predicted séance time for the operation type is used. The planed time at SOP before the operation, the planed operation time and the planed time after the operation are summed up for each of the operation types ("Séance time for the operations in list"). The séance time for the different operation types is then measured up against the remaining time in the planed operation program. Remaining time is the sum of séance time to all of the patients that is in the planed operation program (see figure 8). The first operation type in the vector, "Gives values 1 if séance time is less then the remaining time", which has the value 1 is then picked out being the operation type to the next patient flowing into the operation program. The séance time for this patient is then collected in a stock (see figure 9). If the "Remaining time in operation program" value is less then the séance time for the operation types in "Remaining operations in list" no more patients is placed in the operation program and the inflow of patients to the operation program is stopped by the auxiliary " Stop making operation program".

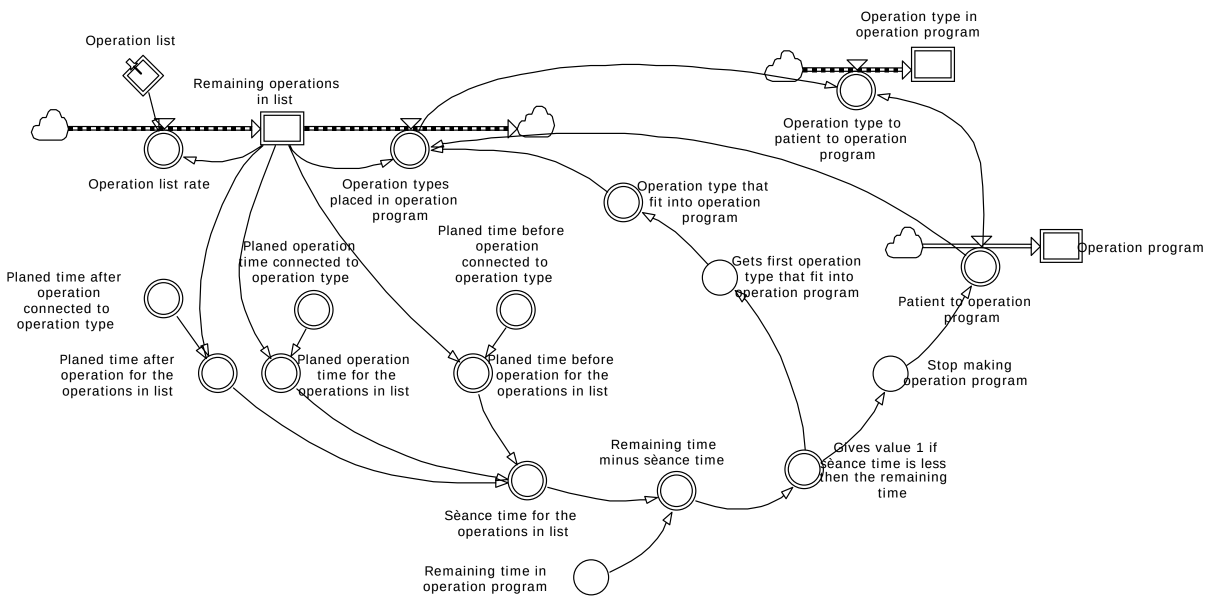


Figure 8: Construction of the planed operation program

Planed time before operation for the operations in list: FOR(p=Operasjonsprogram|IF('Remaning operations in list'[p]<>0;'Planed time before operation connected to operation type'[INDEX('Remaning operations in list'[p])];0<<min>>))

Calculates whether the planed time exceeds the hours pr day shift: Séance time for the operations in list: 'Planed operation time for the operations in list'+'Planed time before operation for the operations in list'+'Planed time after operation for the operations in list'

Operation type that fit into operation program: FOR(i=Operasjonsprogram| 'Gets first operation type that fit into operation program'=i)

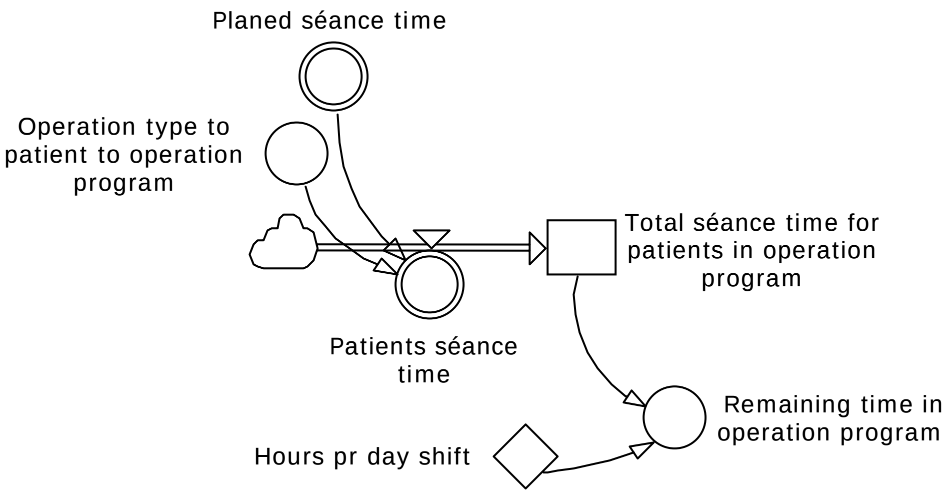


Figure 9: Accumulation of séance time to patients in the operation program

The patients that are going to be operated are placed at the first available position in a vector - “Operation program”. The patients are operated in the order that they are placed in the vector and the operation program is emptied after the shift, meaning that remaining operations in the program are cancelled. Cancelled operations are put into the operation program the next day.

Immediate care line

The operation program of acute patients are not planed and are therefore modelled differently then the elective operation program. Acute patients arrive at the hospital at random times during the day or night. When arriving at hospital the patients gets urgency degree showing how long a patient can wait before getting operated (“patient degree of urgency” in figure 10). The degree can be everything from 0 to over 24 hours. In the model the arriving patient is put into the first vacant place in the vector indicating the line of patients waiting to be operated “Line of immediate care patients” (see figure 10). The patients are not necessary operated in the order they arrive or after the placements they have in the vector. The patient that is to be operated first is decided out from the given degree and the time the patient has spent waiting for an operation (“Waiting time for the patient” in figure 10). The patient that has waited the longest beyond the set degree is moved first in line to be operated. If there are no patients that have waited over their degree the patient that has waited the longest in the queue gets operated first (see figure 10 with equations).

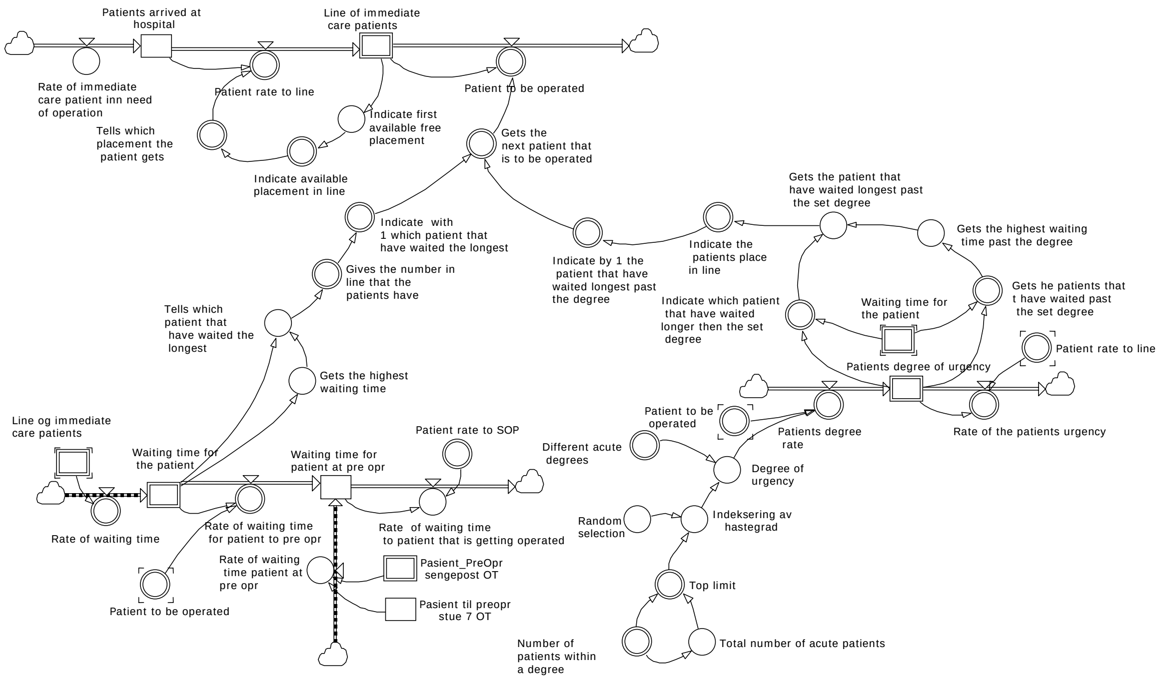


Figure 10: The model over one of the emergency queue lines with the waiting time accumulation and the patient's degree.

<u>*Indicate the first available free place:*</u> SCANEQ('Line of immediate care patients';0)

<u>*Indicate the available place in line for patient*</u>*:* FOR(i=1..10| 'Indicate the first available free place'=i)

<u>*Tells which place in line the patient gets:*</u> IF('Indicate the available place in line for patient'=TRUE;1;0)

<u>*Gives the number in line that the patient have*</u>*:* FOR(i=1..10| 'Tells which patient that have waited the longest'=i)

<u>*Gets the next patient that is to be operated*</u>: FOR(i=1..10| IF(ARRMAX('inidicate by 1 the patient that have waited longest past the degree')>0;'inidicate by 1 the poatient that have waited longest past the degree'[i];'Indicate by 1 which patient that have waited the longest'[i]))

<u>*Indicate the patients place in line*</u>*:* FOR(i=1..10|'Gets the patient that have waited longest past the set degree'=i)

Gets the patient that have waited longest past the set degree: IF(ARRMAX('Indicate which patient that have waited longer than the set degree')>0;SCANEQ('Indicate which patient that have waited longer than the set degree';'Gets the highest waiting time past the degree');0)
Indicate which patient that have waited longer than the set degree: FOR(i=1..10| IF('waiting time for the patient'[i]>='Patients degree of urgency'[i] AND 'Patients degree of urgency'[i]>0;'waiting time for the patient'[i]-'Patients degree of urgency'[i];0))

The acute patients are divided into two groups based on their given urgency degree. One group consist of patients that can wait longer than 8 hours and the other those that are more acute and can not wait that long. The 8 hour limit was set because it is the same length as one working day, meaning that patients arriving at daytime have to be operated during that day. If these patients arrives at night there is one team set of to operate theses patients. The division of the emergency patients has been modelled in two different queues because patients with a degree less then 8 hours are always prioritizes before the other emergency line independent from the waiting time or degree of those patients. The two queues are modelled in the same matter as in figure 10.

The operation types for the emergency patients has been generated equally as the elective ones where all of the emergency operation types arriving at SOP in 2004 has been picked out randomly by a model creating a list of operation types. The list of operation types has then been put into the model in a vector stock. As a patient flows into the line of immediate patients the first value bigger then zero in the vector stock is picked out giving the patients operation type.

3.2.1.2 Calling patients to SOP

Patients in need of an operation arrive at SOP from the surgical bedpost or the emergency room. There are several elements that are needed to be inn place before a patient can be called to SOP.

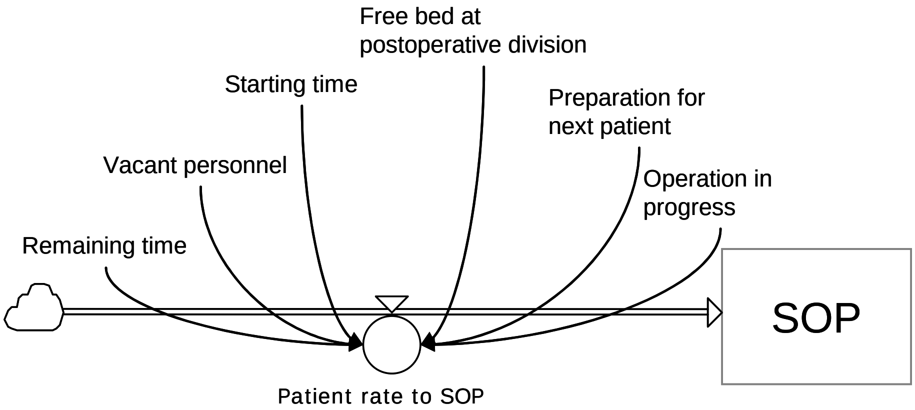


Figure 11: Elements determine the patient flow to SOP

Remaining time

To avoid overtime there has to be enough remaining time of the shift to operate the patient before the patient can flow to SOP. The patient's operation type is used to get the planed séance time for the operation. The day of the week decides which time the shift ends for the different shifts. The ending time for the shift is compared to the time at the different points in the simulation and together with the séance time for the next patient decides whether it is enough time left of the shift to operate the patient.

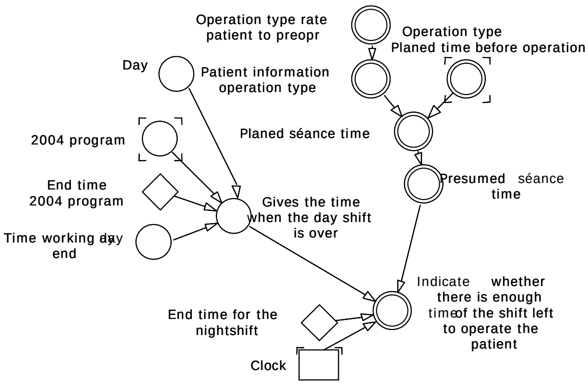


Figure 12: Calculating remaining time.

Vacant personnel

Before a patient can be called to SOP an anaesthesia nurse have to be vacant because the anaesthesia nurse locks the patient in to SOP.

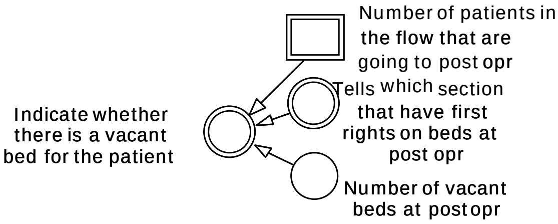


Figure 13: Postoperative beds has to be vacant before a patient can arrive at SOP.

Starting time

The patient can also not be called down to SOP before a set hour in the morning – the starting time in the morning (see figure 16).

Free bed at postoperative division

If a patient is going to the postoperative division after the operation there has to be a vacant bed at the division. To make sure that the division has a bed for the patient the number of occupied beds is counted and subtracted from the total number of beds at the division. If there are vacant beds one bed is held up until the patient arrives at the division. This is modelled to make sure that the patient bed is vacant when arriving at the division (for more detail see chapter 3.2.4).

Preparation for next patient

The personnel at SOP need to prepare for the next patient that is to arrive. The operation and anaesthesia nurse and the anaesthetist are the personnel groups that need to perform the preparation activity before the patient can be called to SOP.

Operation in progress

The last element that needs to be considered is the operation already in progress. If there is a patient at SOP the next patient can not be call to SOP before the operation is coming close to an end. This is modelled by accumulating the time a patient spends at the operation room.

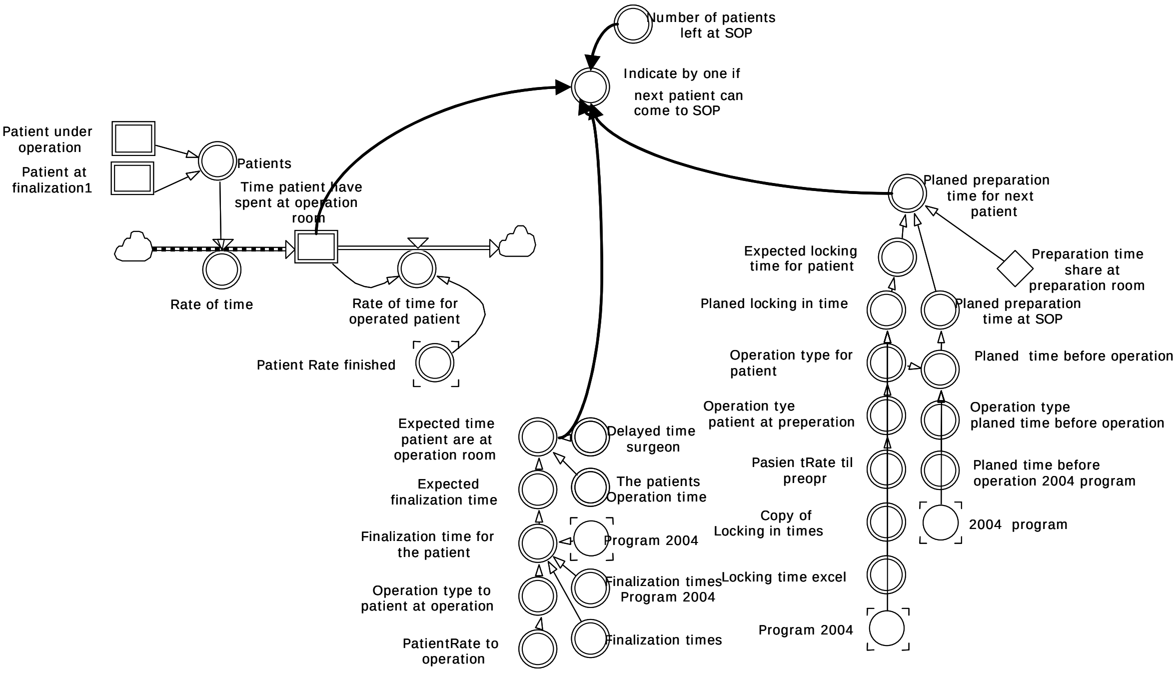


Figure 14: Giving the point in time when there is ready for the next preparation to start.

The accumulated time is compared with the expected operation time for the patient under operation. When the discrepancy between the accumulated time and the expected operation time is equal to or less than the planed preparation time at SOP for the next patient the patient can be called to SOP. To avoid an accumulation of patients at SOP a patient is not called upon if there already is a patient going to the same operation theatre at the activities before the operation activity.

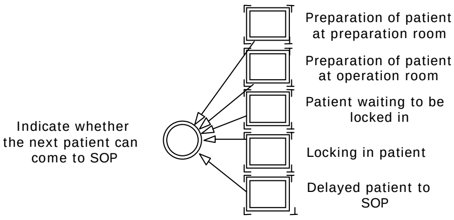


Figure 15: Hindering an accumulation of patients at SOP.

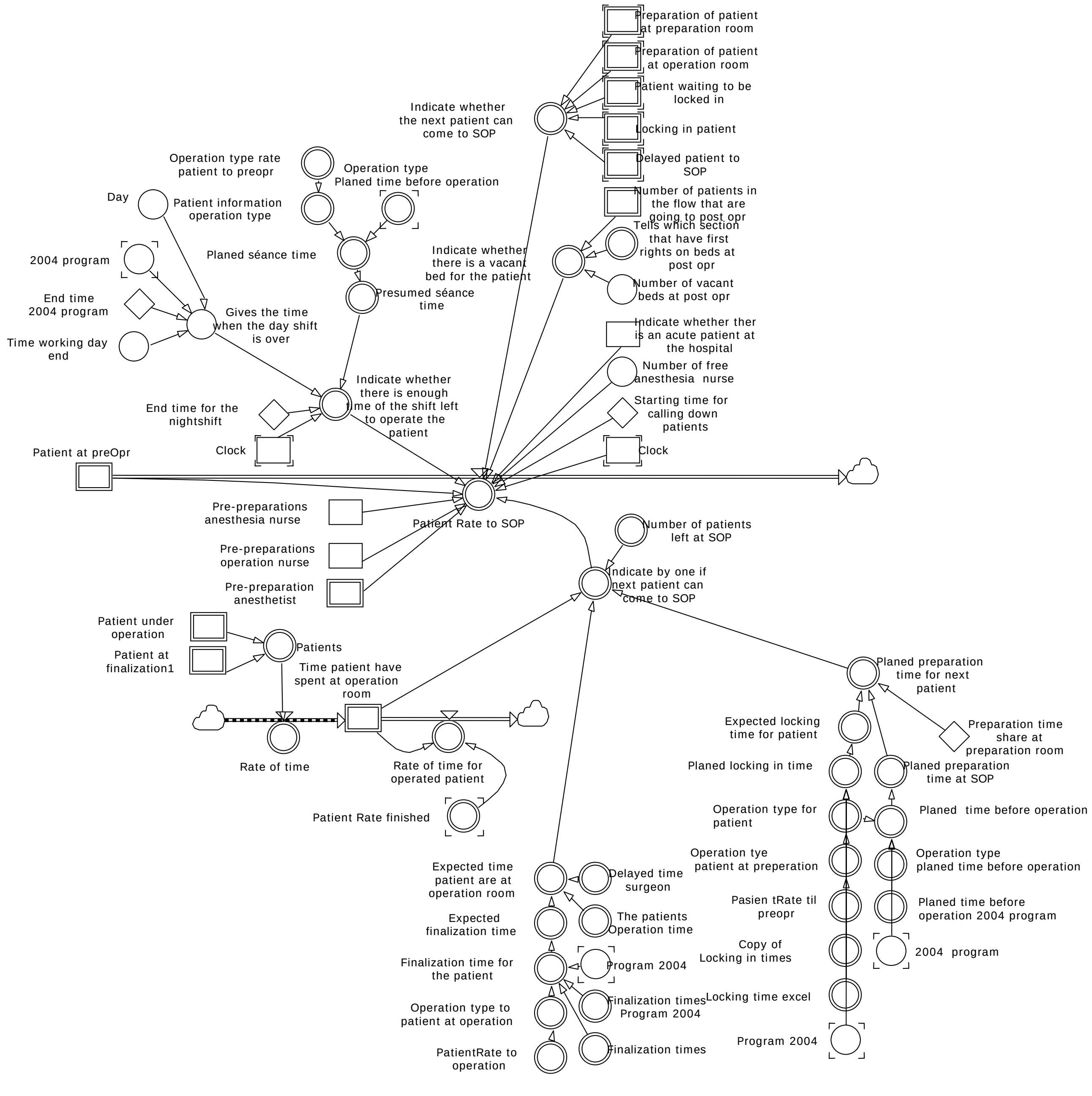


Figure 16: Model over the modelling of calling of patients

<u>*Indicate by one if next patient can come to SOP*</u>: FOR(p=Stuer | IF('Number of patients left at SOP'[p]=1;1; IF(('Expected time patient are at operation room'[p]-'Time patient have spent at operation room'[p])<('Planed preparation time for next patient'[p]) AND ('Expected time patient are at operation room'[p]-'Time patient have spent at operation room'[p])>1;1;0)))

<u>*Finalization time for the patient*</u>: FOR(p=Stuer | IF('Operation type to patient at operation'[p]<>0 AND Excelprogram=0;'Finalization times'[INDEX('Operation type to patient at operation'[p])]; IF(Excelprogram>0 AND 'Operation type to patient at operation'[p]<>0;'Finalization times excelprogram'[INDEX('Operation type to patient at operation'[p])];0<<hr>>)))

Expected time patient are at operation room: FOR(p=Stuer | 'Expected finalization time'[p]+('The patients Operation time'[p] DIVZ0 3)+'Delayed time surgeon'[p])

Indicate whether there is a vacant bed for the patient: FOR(p=Stuer|IF(('Number of vacant beds at post opr'>0 OR 'Tells which section that have first rights on beds at post opr'[OT]=TRUE) AND 'Number of patients in the flow that are going to post opr'[p]>0;1; IF('Number of patients in the flow that are going to post opr'[p]=0;1;0)))

3.2.1.3 The locking system

There are three locks into SOP which are used to lock the patient into, and out of SOP. The locks are divided on the four sections, the three sections (OT, Head/Neck and General Surgery) have their specific lock to use and the Thorax section can use all of them as long as they are free. The different section can use other sections locks as long as the section “owning” the lock does not use it. If there are many patients outside the vacant lock the section with the patients that have waited the longest gets to use the free locks first.

To assure that the right patient flows to the right operation theatre and that the patient’s information follows the patient there has been modeled one locks for each operation theatre. Restrictions have been modeled at the inflows to the locks to make sure that only three patients can be locked in at the same time. The figures and equations below describe these restrictions and show how this has been solved in the model (see figure 17 and figure 18).

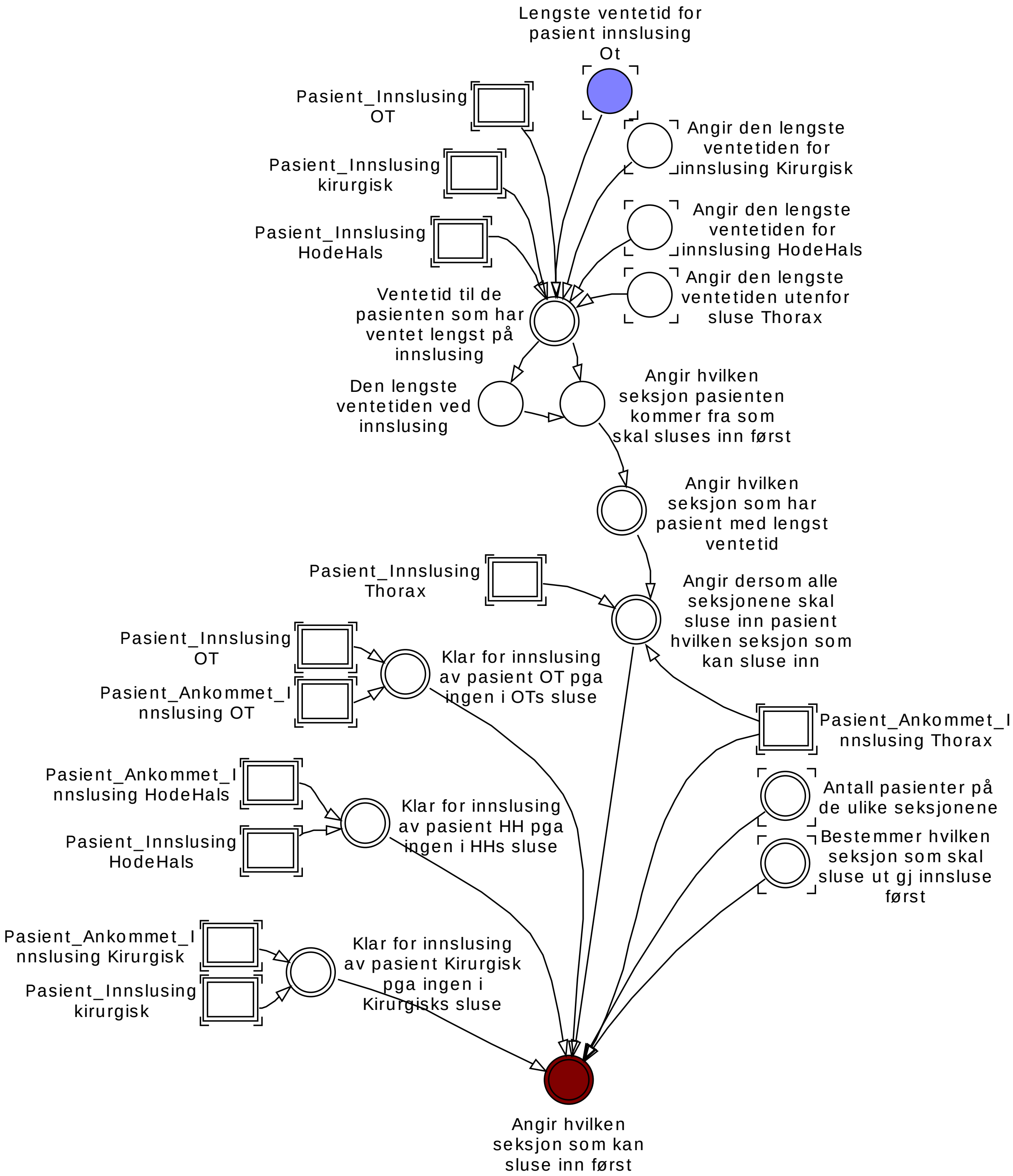


Figure 17: The modelling of the locking in prioritizing process

<u>*Ventetid til de pasientene som har ventet lengst på innslusing:*</u> FOR (i = Seksjoner | IF (NUMERICAL(i) = NUMERICAL(OT); IF(ARRSUM('Pasient_Innslusing OT')=0;'Lengste ventetid for pasient innslusing Ot';0); IF(NUMERICAL(i)=NUMERICAL(HodeHals); IF(ARRSUM('Pasient_Innslusing HodeHals')=0;'Angir den lengste ventetiden for innslusing HodeHals' ;0) ; IF (NUMERICAL(i)= NUMERICAL (Kirurgisk) ;IF (ARRSUM ('Pasient_Innslusing kirurgisk')=0;'Angir den lengste ventetiden for innslusing Kirurgisk';0);'Angir den lengste ventetiden utenfor sluse Thorax'))))

Angir hvilken seksjon som har pasient med lengst ventetid: FOR(i=Seksjoner| 'Angir hvilken seksjon pasienten kommer fra som skal sluses inn først'=NUMERICAL(i))

Angir dersom alle seksjonene skal sluse inn pasient hvilken seksjon som kan sluse inn: FOR(i=Seksjoner | IF((ARRSUM ('Pasient_Ankommet_Innslusing Thorax')>0 OR ARRSUM ('Pasient_Innslusing Thorax')>0) AND 'Angir hvilken seksjon som har pasient med lengst ventetid'[i]=TRUE;1;0))

Angir hvilken seksjon som kan sluse inn først:

FOR(i=Seksjoner|IF(NUMERICAL(i)=NUMERICAL(OT);IF(ARRSUM('Klar for innslusing av pasient OT pga ingen i OTs sluse')>0 AND (('Bestemmer hvilken seksjon som skal sluse ut gj innsluse først'[OT]>0 OR 'Bestemmer hvilken seksjon som skal sluse ut gj innsluse først'[Thorax]>0) OR ((ARRSUM('Antall pasienter på de ulike seksjonene')+ARRSUM('Bestemmer hvilken seksjon som skal sluse ut gj innsluse først'))>0));0; IF(ARRSUM('Klar for innslusing av pasient OT pga ingen i OTs sluse')>0 AND ARRSUM('Angir dersom alle seksjonene skal sluse inn pasient hvilken seksjon som kan sluse inn')>0 AND 'Angir dersom alle seksjonene skal sluse inn pasient hvilken seksjon som kan sluse inn'[OT]=0;0; IF(ARRSUM('Klar for innslusing av pasient OT pga ingen i OTs sluse')=0;0;1)));
IF(NUMERICAL(i)=NUMERICAL(HodeHals); IF(ARRSUM('Klar for innslusing av pasient HH pga ingen i HHs sluse')>0 AND (('Bestemmer hvilken seksjon som skal sluse ut gj innsluse først'[HodeHals]>0 OR 'Bestemmer hvilken seksjon som skal sluse ut gj innsluse først'[Thorax]>0) OR ((ARRSUM('Antall pasienter på de ulike seksjonene')+ARRSUM('Bestemmer hvilken seksjon som skal sluse ut gj innsluse først'))>0));0; IF(ARRSUM('Klar for innslusing av pasient HH pga ingen i HHs sluse')>0 AND ARRSUM('Angir dersom alle seksjonene skal sluse inn pasient hvilken seksjon som kan sluse inn')>0 AND 'Angir dersom alle seksjonene skal sluse inn pasient hvilken seksjon som kan sluse inn'[HodeHals]=0;0; IF(ARRSUM('Klar for innslusing av pasient HH pga ingen i HHs sluse')=0;0;1)));
IF(NUMERICAL(i)=NUMERICAL(Kirurgisk);IF(ARRSUM('Klar for innslusing av pasient Kirurgisk pga ingen i Kirurgisks sluse')>0 AND (('Bestemmer hvilken seksjon som skal sluse ut gj innsluse først'[Kirurgisk]>0 OR 'Bestemmer hvilken seksjon som skal sluse ut gj innsluse først'[Thorax]>0) OR ((ARRSUM('Antall pasienter på de ulike seksjonene')+ARRSUM('Bestemmer hvilken seksjon som skal sluse ut gj innsluse først'))>0));0; IF(ARRSUM('Klar for innslusing av pasient Kirurgisk pga ingen i Kirurgisks sluse')>0 AND ARRSUM('Angir dersom alle seksjonene skal sluse inn pasient hvilken seksjon som kan sluse inn')>0 AND 'Angir dersom alle seksjonene skal sluse inn pasient hvilken seksjon som kan sluse inn'[Kirurgisk]=0;0;IF(ARRSUM('Klar for innslusing av pasient Kirurgisk pga ingen i Kirurgisks sluse')=0;0;1)));IF(ARRSUM ('Pasient_Ankommet_Innslusing Thorax')>0 AND 'Angir dersom alle seksjonene skal sluse inn pasient hvilken seksjon som kan sluse inn'[Thorax]>0 AND (ARRSUM('Bestemmer hvilken seksjon som skal sluse ut gj innsluse først')=0 AND ARRSUM('Antall pasienter på de ulike seksjonene')=0);1;0)))))

The auxiliary, “Angir hvilken seksjons som kan sluse inn først”, is connected to the inflow to the locking activity, as showed in the figure below. When the section is allowed to lock a patient in the patient that has waited the longest gets locked in first.

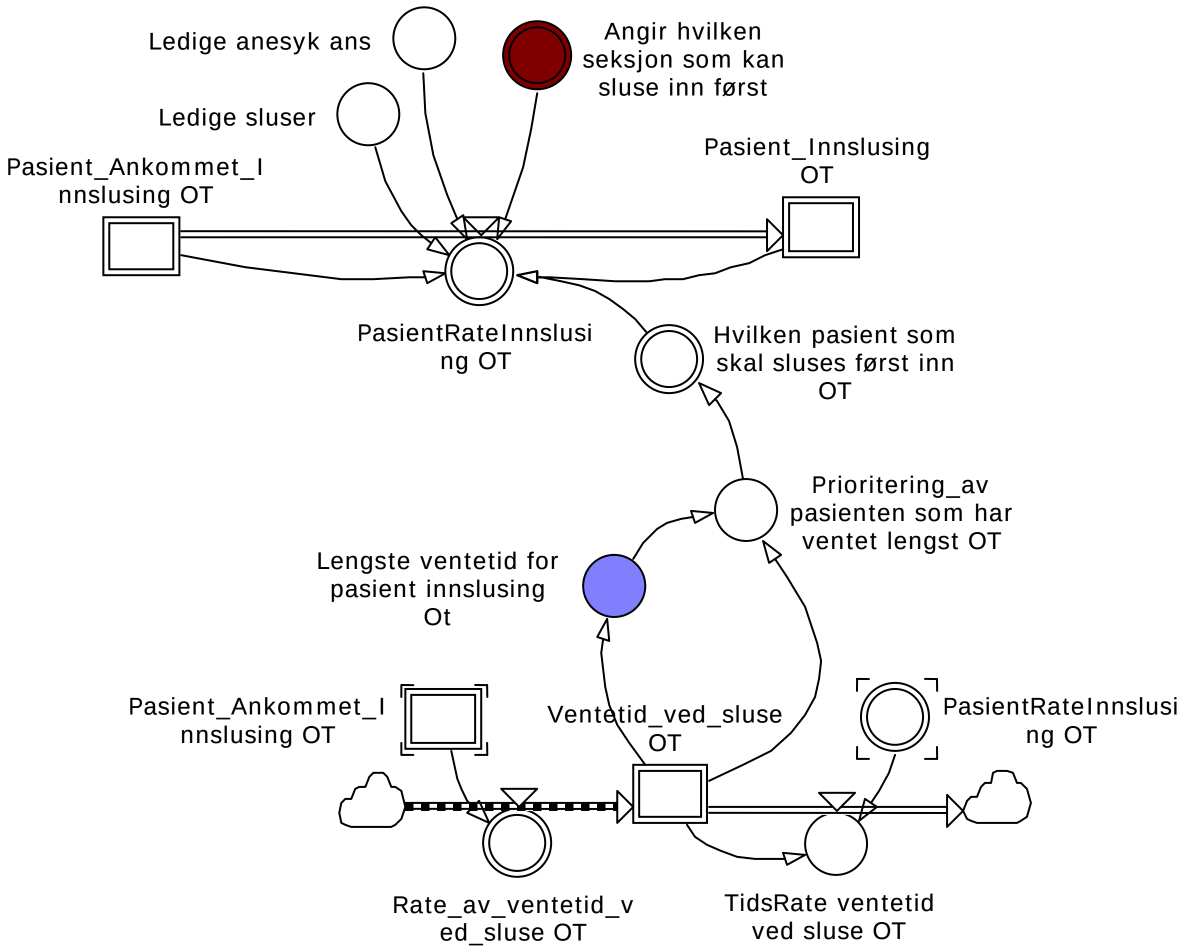


Figure 18: Shows the connection between the locking in prioritizing process and the patient flow for the OT section.

<u>PasientRateInnslusing OT:</u> FOR(p=Stuer | IF ('Angir hvilken seksjon som kan sluse inn først'[OT] = 1 AND 'Ledige sluser'>=1 AND 'Hvilken pasient som skal sluses først inn OT'[p]=TRUE AND 'Ledige anesyk ans'>=1;'Pasient_Ankommet_Innslusing OT'[p];0))

Some patients do not need to go to the postoperative division, but can go straight back to the bedpost. These patients use the same locks as those being locked in are prioritized before those being locked in to SOP. Equal to the locking in restrictions all of the patients that need to go out through the locks are counted and if there are fewer free locks then patients the one that have waited the longest gets locked out first.

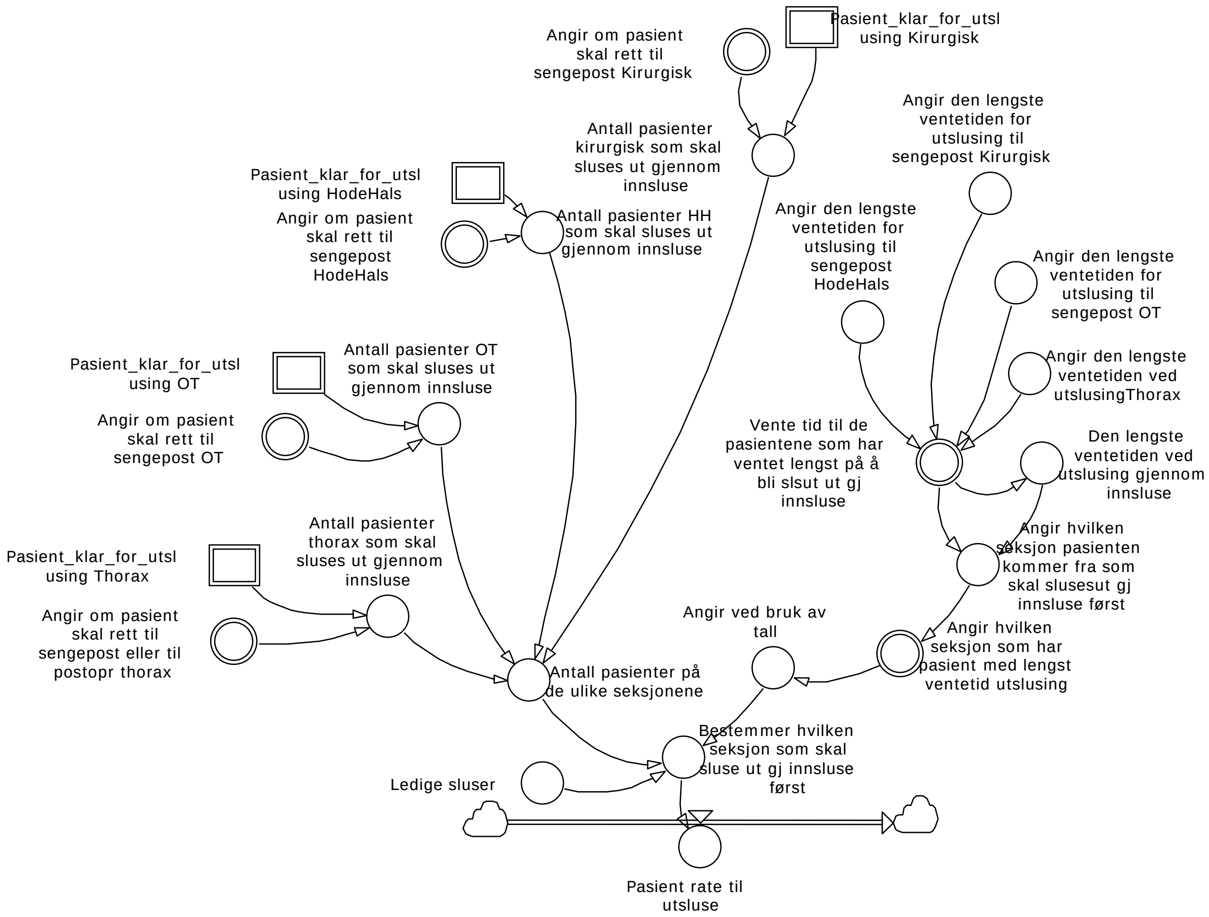


Figure 19: Model over restrictions for locking patients out of SOP

<u>*Antall pasienter på se ulike seksjonene:*</u> FOR (p=Seksjoner| IF(NUMERICAL(p)= NUMERICAL(OT); ARRSUM('Antall pasienter OT som skal sluses ut gjennom innsluse'); IF(NUMERICAL(p) =NUMERICAL (HodeHals); ARRSUM('Antall pasienter HH som skal sluses ut gjennom innsluse'); IF(NUMERICAL(p)=NUMERICAL(Kirurgisk);ARRSUM('Antall pasienter kirurgisk som skal sluses ut gjennom innsluse');ARRSUM('Antall pasienter thorax som skal sluses ut gjennom innsluse')))))

Bestemmer hvilken seksjon som skal sluse ut gj innsluse først: FOR(i=Seksjoner| IF(ARRSUM('Antall pasienter på de ulike seksjonene')>='Ledige sluser' AND 'Ledige sluser'>=1;'Angir ved bruk av tall'[i];IF(ARRSUM('Antall pasienter på de ulike seksjonene')<'Ledige sluser' AND ARRSUM('Antall pasienter på de ulike seksjonene')>0;1;0)))

3.2.2 Model description in more detail – personnel flow

The personnel consist of personnel groups divided into different employment positions. Some of the personnel have specific operation theatres within their section that they attend to. The personnel groups are modelled separately and these models consist of the different employment positions or roles. It is important to divide the roles because they have different responsibilities, costs and perform different activities. One example is the anaesthetist which can be an assistant or a chief. The different positions perform mostly the same activities but have some which are distinct for their employment position, their unit costs are also different. The different employment positions have therefore been modelled separately. This is also important because missing personnel will hinder a smoothly patient flow.

Some of the personnel have rolls that indicate a responsibility for more than one operation theatre while others only attend to one. Modelling the division of responsibilities and operation theatre connection makes the model more veritable because the personnel are divided into these different roles and responsibilities in the real world. The modelling structure also leads to a more accurate cost accumulation. Adding personnel to the total model will also make it easier to distinguish policies effects on resources. Policies that might seem reasonable when just having the patient flow can give other results when resources are added.

There are some elements that are modelled similar in the different personnel models. Prioritizing activities are one of these similarities. At each model the stocks represents an activity the personnel performs. There can be situations where a resource is simultaneously needed at several activities. To hindering negative values in the stock of available resource there is a need for prioritizes which are connected to the inflow to each activity stock. The prioritizes are made differently at the different personnel models depending on the personnel group and its responsibilities, but in general prioritize the activity that is most important considering the patient flow. Some activities are prioritized before others based on information from interviews and from logical assumptions based on how the patient flow functions. The figure below illustrates prioritises that limits the inflow of operation nurses to prepare for the next patient. The nurse has to prioritize patients that are already at SOP before the nurse can perform the preparation for the next patient activity. The nurse also has to prioritize lunch and going home compared to performing an activity.

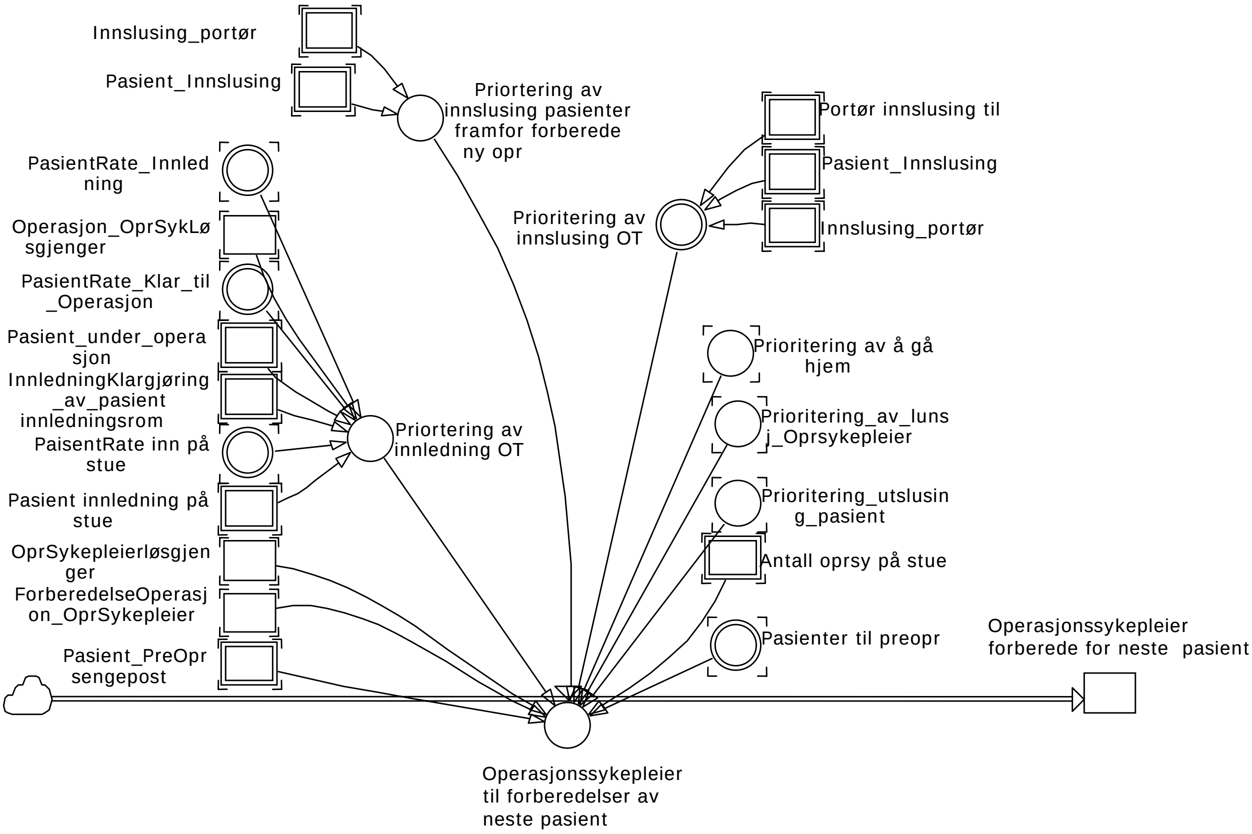


Figure 20: Limitations of flows to activities

Some resources are modelled with a responsibility for several operation theatres. These models are also modelled with the mentioned prioritizes but also include prioritizes between the different operation theatre which is needed if there are several patients inn need of the resource at the same activity only different operation theatres. The patient that has waited the longest at the activity needs to bee prioritised. If the waiting times of the patients are equal one of them is chooses first.

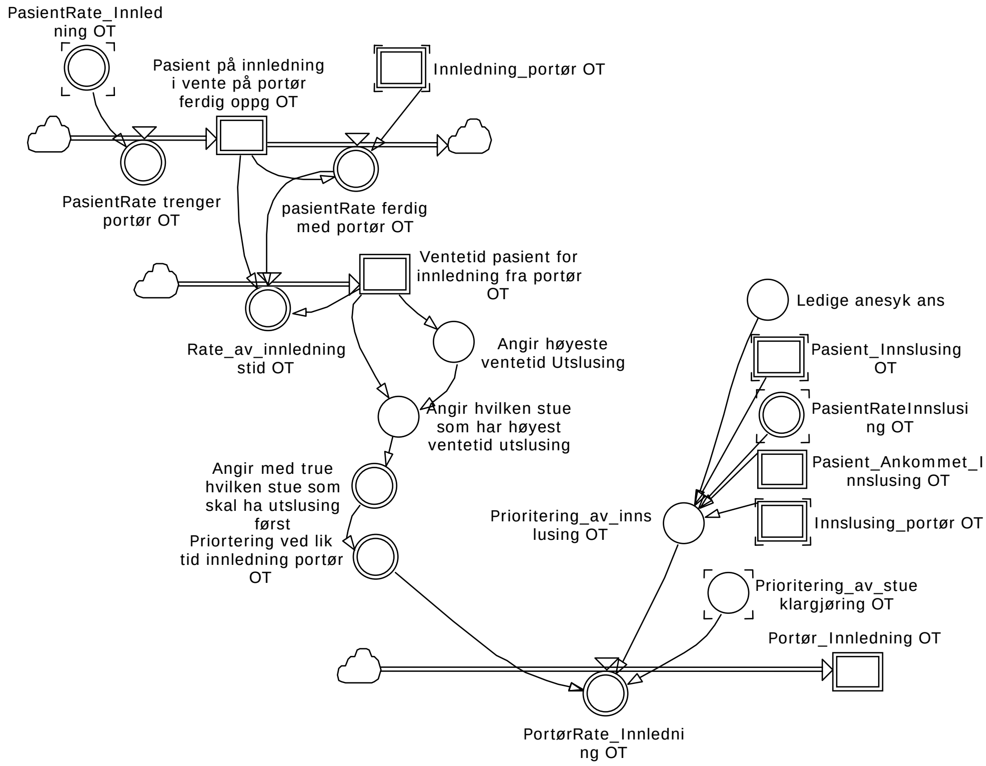


Figure 21: Prioritizing the patient that have waited the longest for the activity

Another similarity between the models is the need to avoid more then one resource within a personnel group and position performing the same activity for the same patient. This is hindered in the inflow to the activity where the performance level is checked before the resource can flow into to the activity. If a performance level is not equal to zero the inflow to the activity is stopped.

Some of the personnel models are also modelled with home duty. The level of the stock of resources at home duty rises with a set amount of resources (Antall ressurser på hjemmevakt) when the resources at the shift is zero (Ressurs ferdig på jobb). The resource is needed to perform activities at SOP when acute patients arrive at the hospital and returns to home duty after the operation and performance of tasks connected to the operation (RessursRate hjem etter akuttopr). When the level of resources (Ressurs på jobb) raise above zero, indicating the start of a new shift, the resources at home duty flows out of the level.

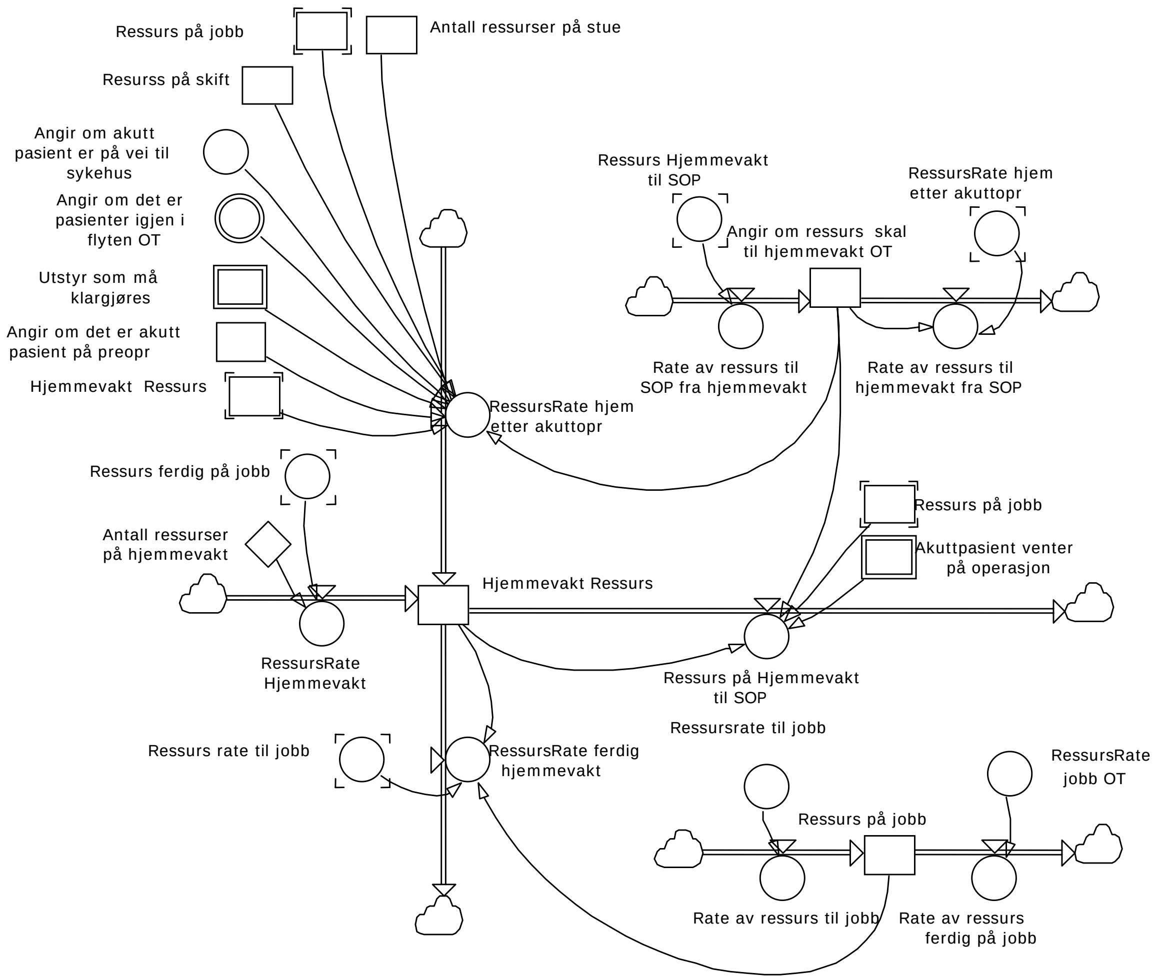


Figure 22: Model of Home Duty

RessursRate hjem etter akuttopr: IF('Hjemmevakt Ressurs OT'>0 OR 'Angir om ressurs skal til hjemmevakt OT'=0 OR 'Antall ressurser på stue'>0;0; IF(Ressurs på skift>0 AND 'Utstyr som må klargjøres=0 AND 'Hjemmevakt Ressurs=0 AND 'Angir om ressurs skal til hjemmevakt OT'>0 AND (('Angir om det er akutt pasient på preopr OT'=0 AND 'Angir om akutt pasient er på vei til sykehus'=0 AND 'Angir om det er pasienter igjen i flyten=1) OR 'Resurss på jobb'>=1);1;0))

Ressurs på Hjemmevakt til SOP: IF(ARRSUM('Akuttpasient venter på operasjon')>0 AND 'Ressurs på jobb'=0 AND 'Angir om ressurs skal til hjemmevakt OT'=0;'Hjemmevakt Ressurs';0)

RessursRate ferdig hjemmevakt: IF('RessursRate til jobb OT'>0 OR 'Ressurs på jobb'>0;'Hjemmevakt Ressurs';0)

3.2.2.1 Anesthesia nurse

The anaesthesia nurses are divided into three roles. On role is the “responsible” nurse who is mainly responsible for the patient at activities outside the operating theatre like preparing for the patients arrival, the locking activity, preparations of the patient and cleaning equipment. Another role is the nurse involved with the activities that take place at the operating theatre like finishing the preparation, operation and the finalization of the operation. The last role is the “trade” anaesthesia which is modelled separately from the other nurses because she/he have other responsibilities, like administrative responsibilities, in addition too those that the other nurses have. When the nurses need help the trade anaesthesia assists them at performing different tasks.

There is one nurse at each of the operating theatres and two responsible nurses that are divided on three rooms. This means that one nurse is responsible for activities connected to two operation theatres. This nurse has been modelled separately from the other responsible nurse to make sure that the areas of responsibilities are not mixed between the two responsible nurses. The responsible nurses can help each other but prioritize the patients that belong to “their” operating rooms. The model of the responsible nurse is connected to the model of the nurses at the operation theatre because the responsible nurse replace and perform the tasks of the nurses at the operating theatre when they have lunch.

The model, showed in figure 23, is of the anaesthesia nurse responsible for one operation room and the nurse at the operation theatre. The activities for the nurse responsible for tasks at the operation theatre are connected together because one activity leads to the other following the patient flow. Activities performed by the responsible nurse are not always stream lined and are therefore not connected to each other.

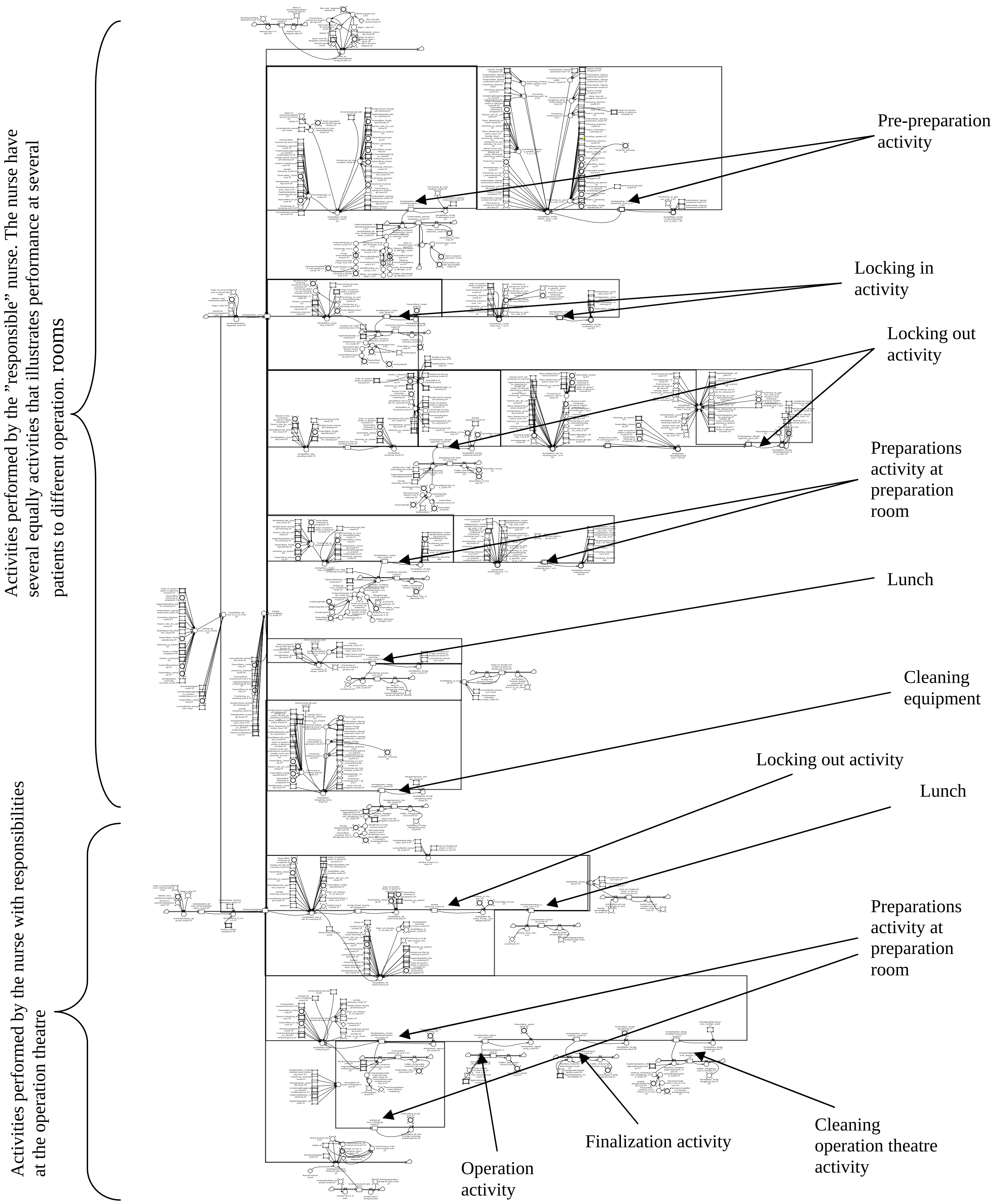


Figure 23: Model over anaesthesia nurses, showing activities performed by one responsible nurse and one performing activities connected to the performance of the operation.

3.2.2.2 Operation nurse

The operation nurses are divided into the roles; sterile, “tramp”, middle watch and trade operation nurse. For each operation team there is one sterile nurse and one tramp which have different responsibilities concerning the patient flow. The sterile nurse is responsible for activities dealing with the operating theatre like preparing the room for the next patient, assisting during the operation, awakening the patient after the operation and cleaning the operating theatre. The tramp also participates at the operating theatre during the operation and awakening and in addition to this prepares for the next operation, assists in the preparations at the pre-operation room, locks the patient out of SOP and cleans equipment. The tramp nurse assist under locking patients inn to SOP if the hospital orderly is tide up with other tasks (see figure 24).

The OT section which has more then one shift, have a middle watch nurse who works half of both shifts. The nurse assists at the different operation teams when operation nurses have lunch performing the activities of the nurse that is having a brake. The nurse also assists the teams in activities outside the operation theatre when not replacing those at lunch. The Thorax sections middle nurse work the day shift, but assist in the same way as the nurse at the OT section.

The trade nurse also assists during the operation nurses lunchtime. In addition, the nurse assists in pre-preparations of the patients. The trade nurse has also additional task which does not include patients like administrative tasks, purchase of equipment and so on. These activities have been included in the model because they make the nurse unavailable which might have an effect on the patient flow.

The figures below shows the system dynamic models of the operation nurse, middle watch and trade nurse

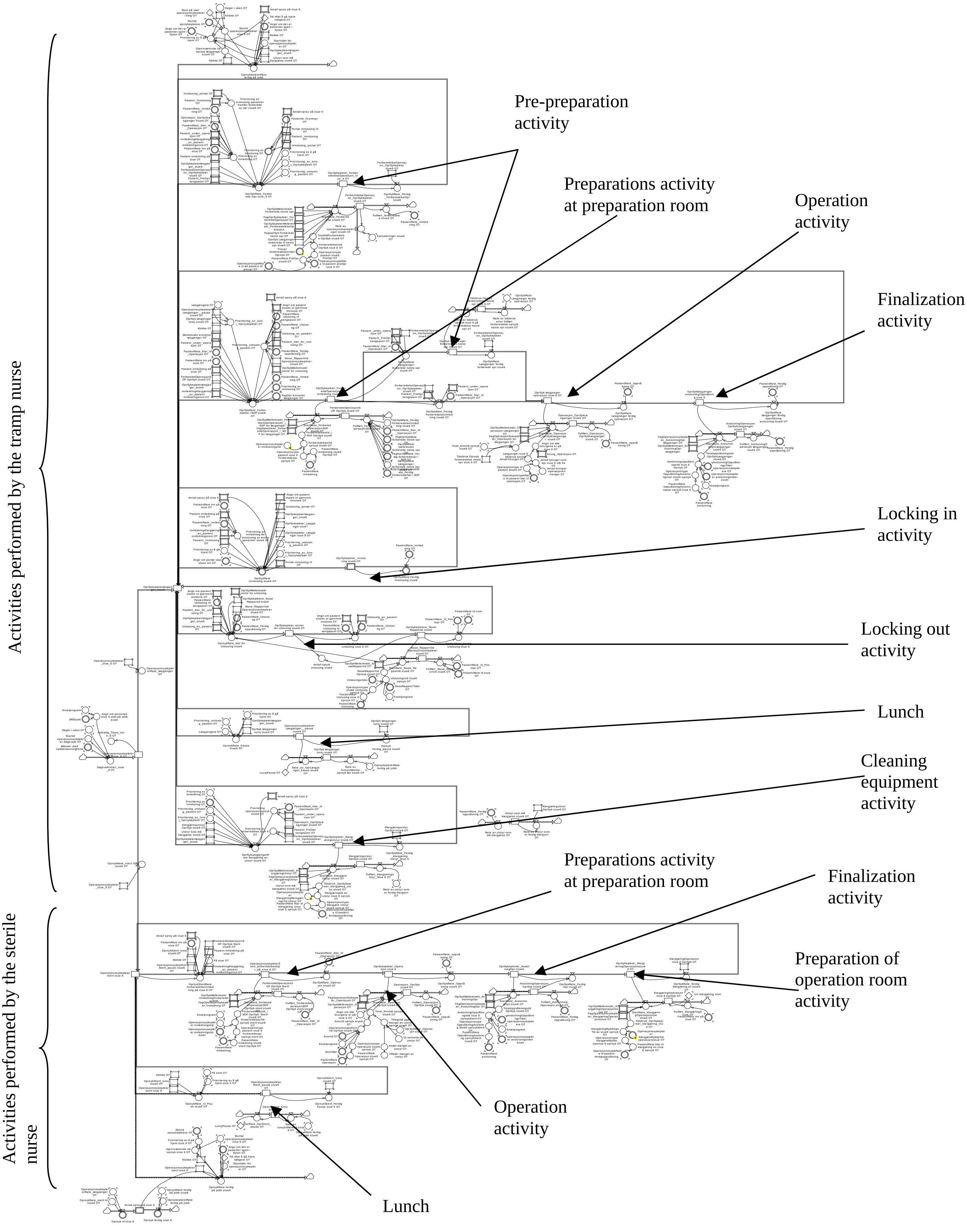


Figure 24: Model over the operation nurses that belong to one operation team.

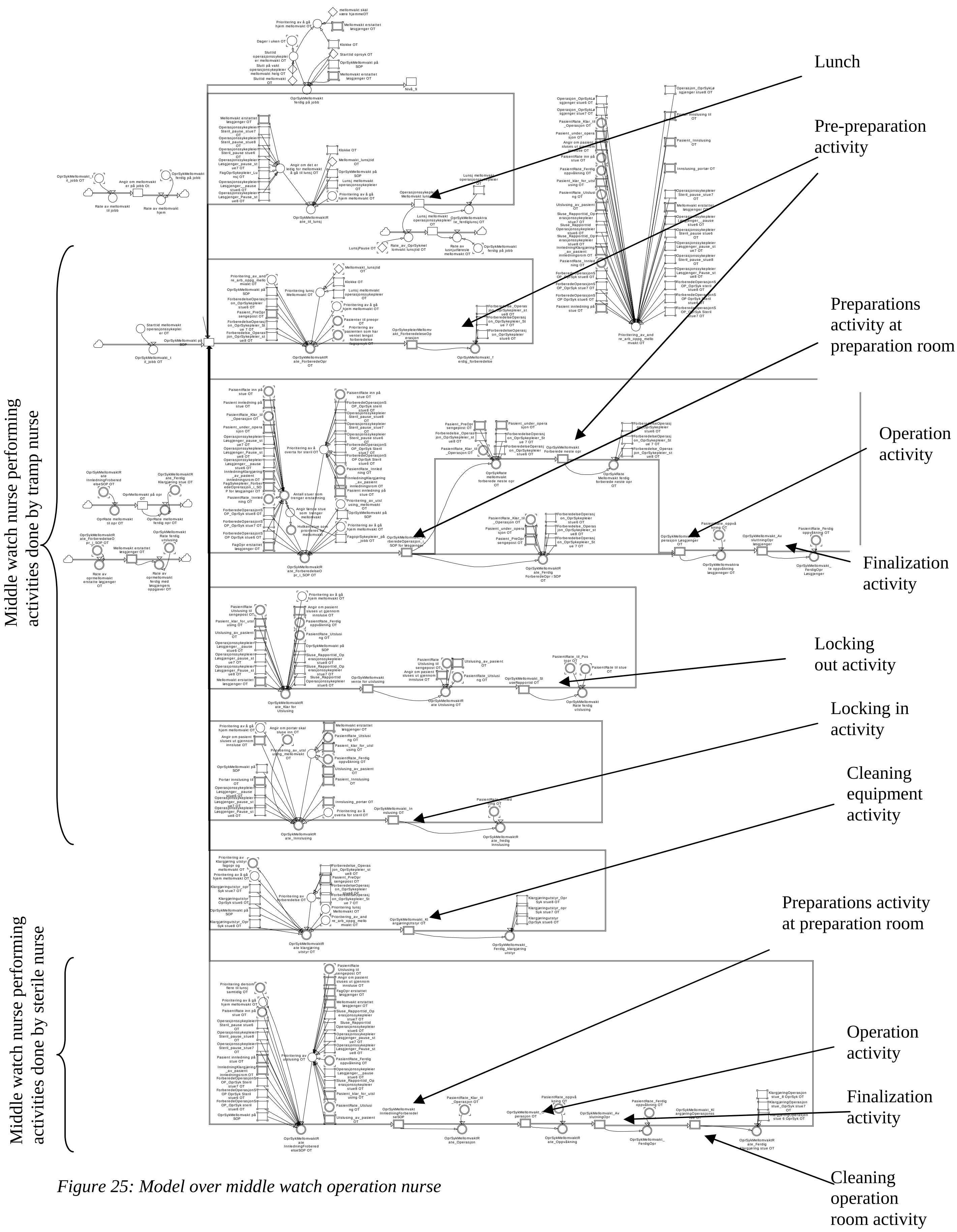


Figure 25: Model over middle watch operation nurse

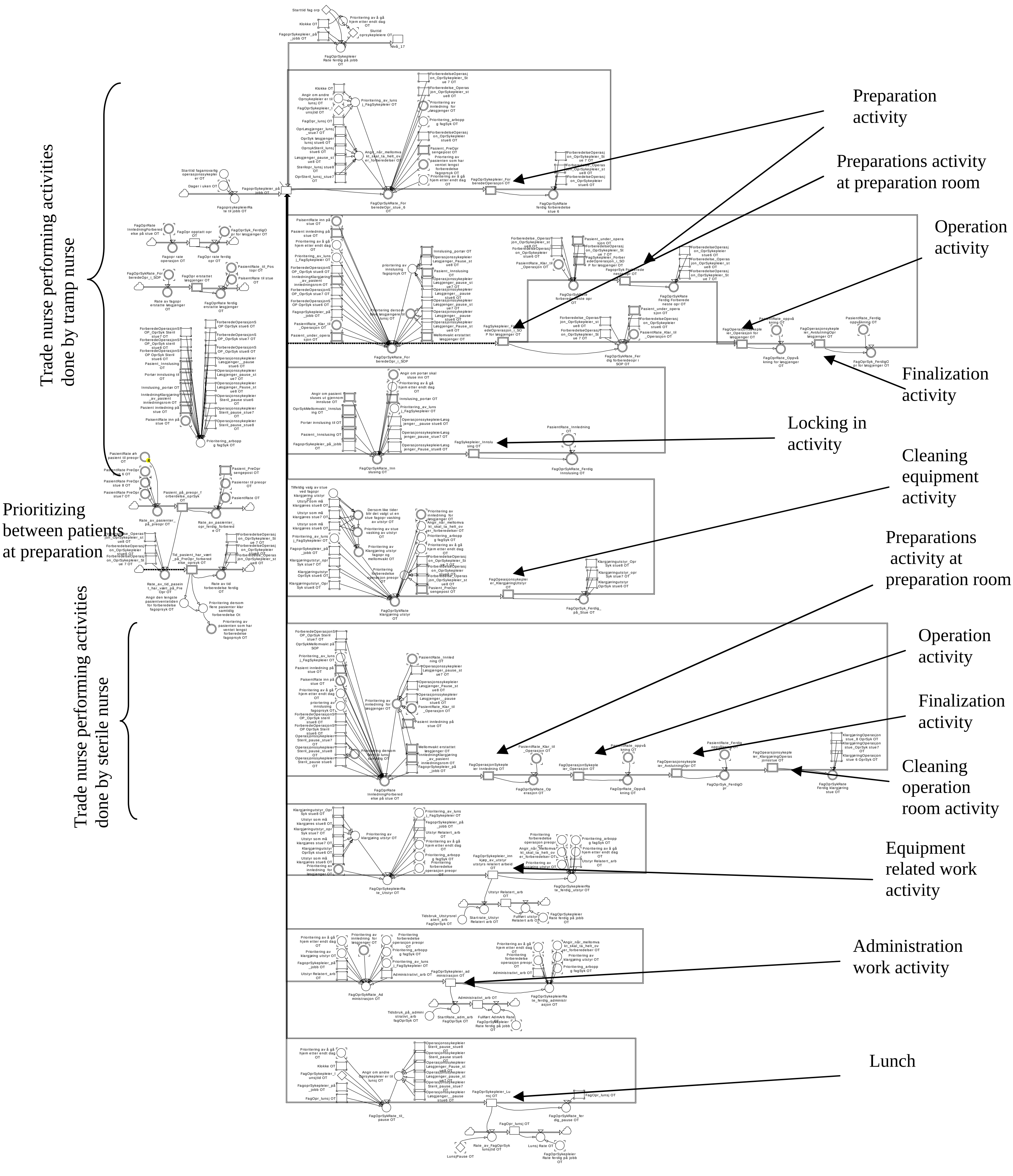


Figure 26: Model over trade operation nurse

3.2.2.3 Anaesthetist

The anaesthetist can be an assistant or chief physician. They have the same responsibilities except for one activity, writing reports to the bedpost, which only the chief physician does. The two roles have also different units cost and are therefore modelled apart. The anaesthetist performs activities like preparation for the operation before the patient has arrived at SOP, giving anaesthesia before the operation, parts of the operation, the awakening of the patient and sometimes follows the patient through the locks. After the patient has left SOP the anaesthetist checks up on the patient at the preoperative division and follows up the patient outside SOP. These activities have been included because they make the anaesthetist unavailable for the operation teams and can cause problems for the patient flow. The activities also generate cost which is included in the total operation costs of the patients. The anaesthetist assists all of the operation teams within their section and is not connected to one specific operation team.

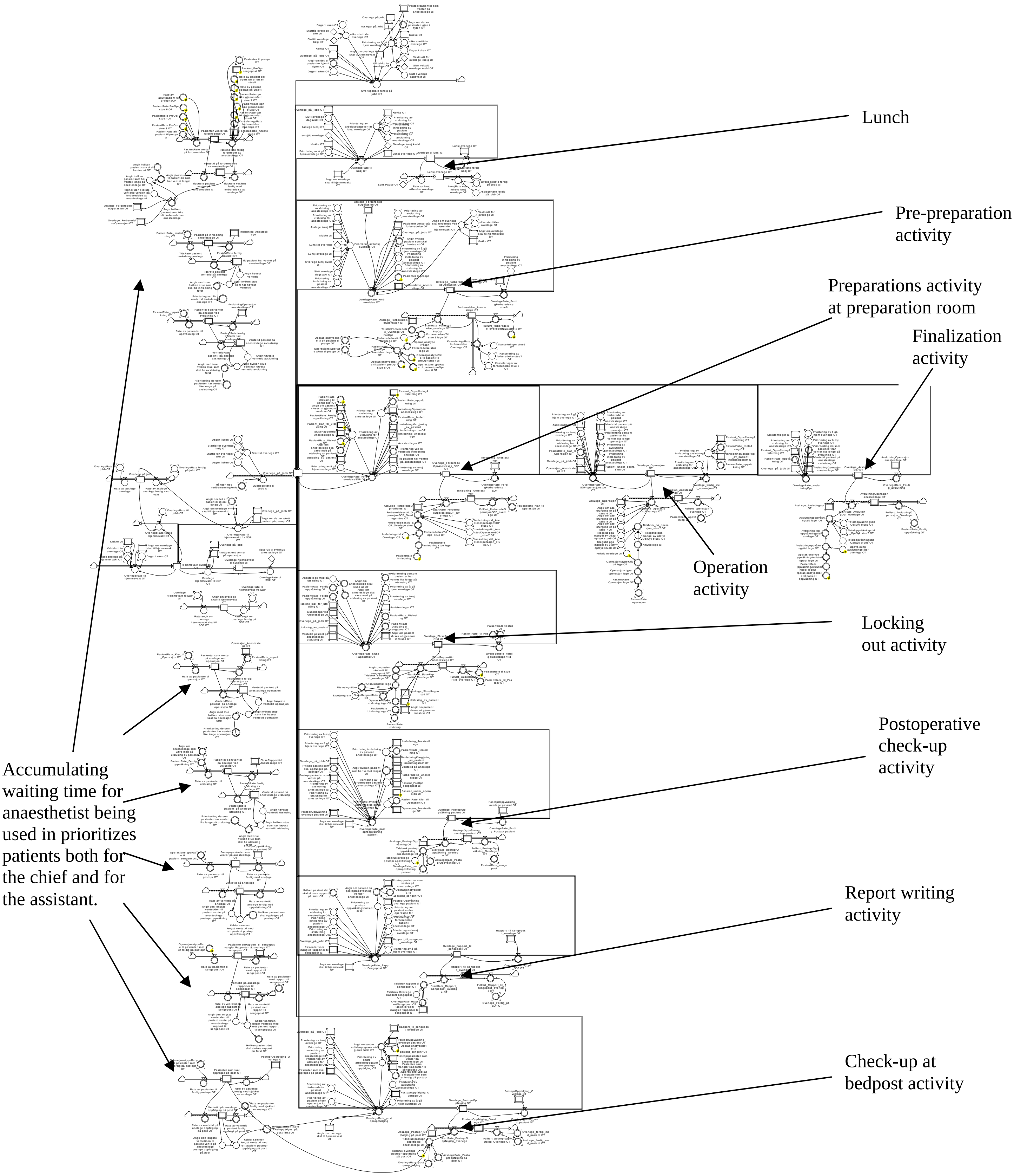


Figure 27: The model of the anaesthetist chief.

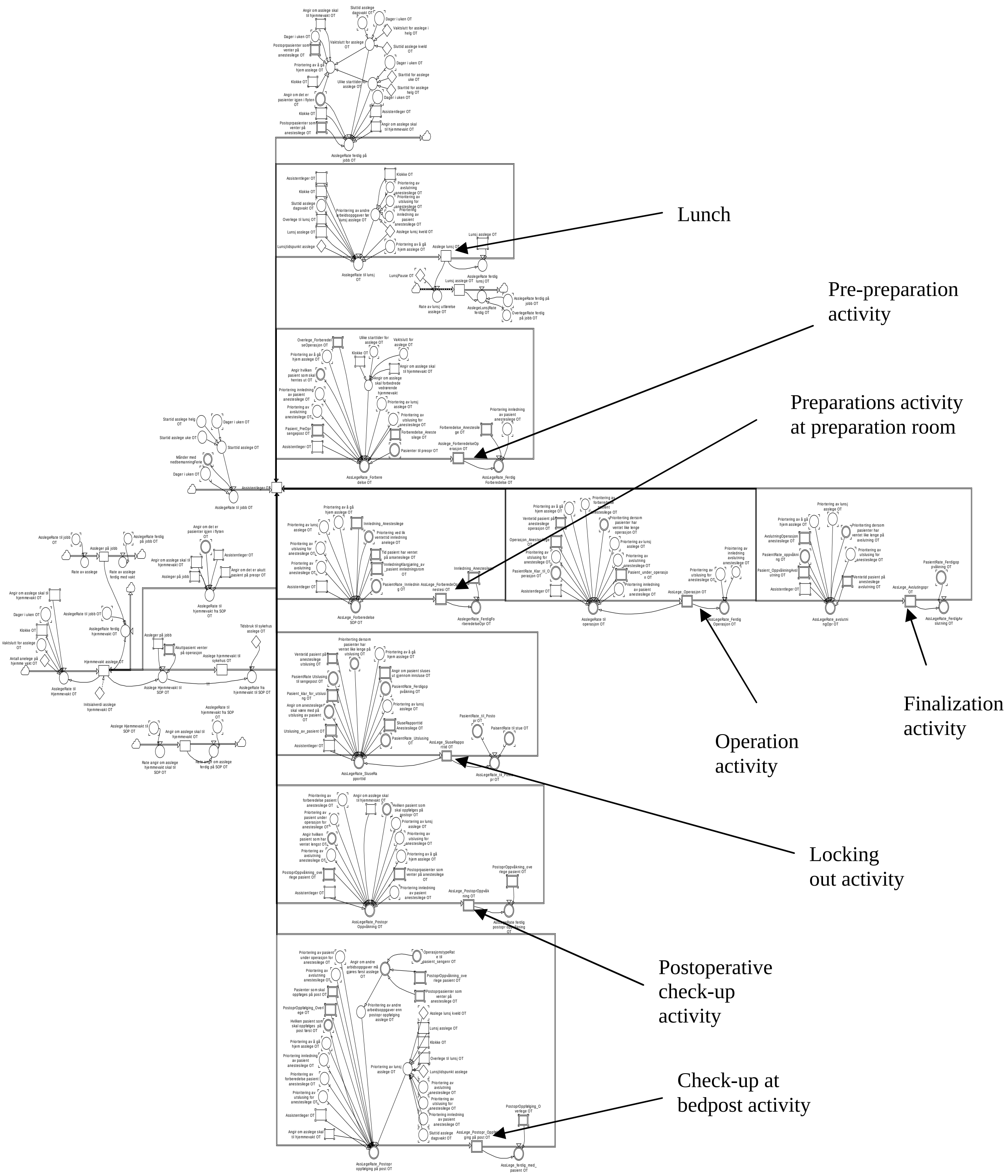


Figure 28: The model over the anaesthetist assistant.

3.2.2.4 Assistant and hospital orderly

Assistants and hospital orderlies are part of the support function at the hospital and are lent in at SOP to perform specific tasks. The hospital orderlies assist in locking in the patients and preparation of the patient before the operation. They are also responsible for cleaning equipment and tidying the operation theatre. The assistant and hospital orderly are modelled separately because they perform different tasks and have different unit costs. There are not enough assistants or hospital orderlies to perform task at each of the different operation rooms at the same time. To avoid negative stock values there have been modelled prioritizes at each of the inflows to the stocks. Tasks involving patients are prioritized first and the patient that has waited the longest gets assisted first.

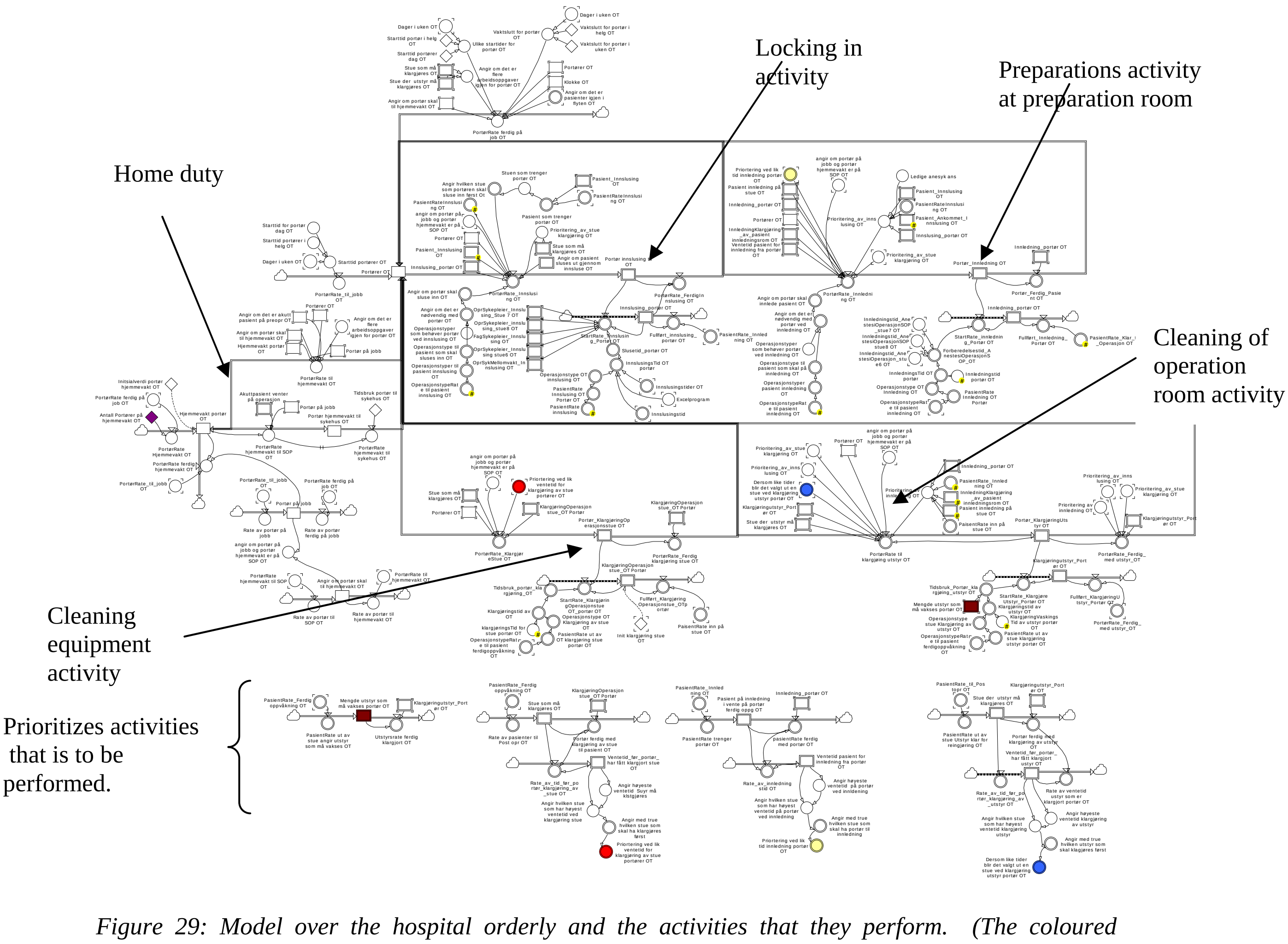


Figure 29: Model over the hospital orderly and the activities that they perform. (The coloured auxiliaries shows the connection to the flows)

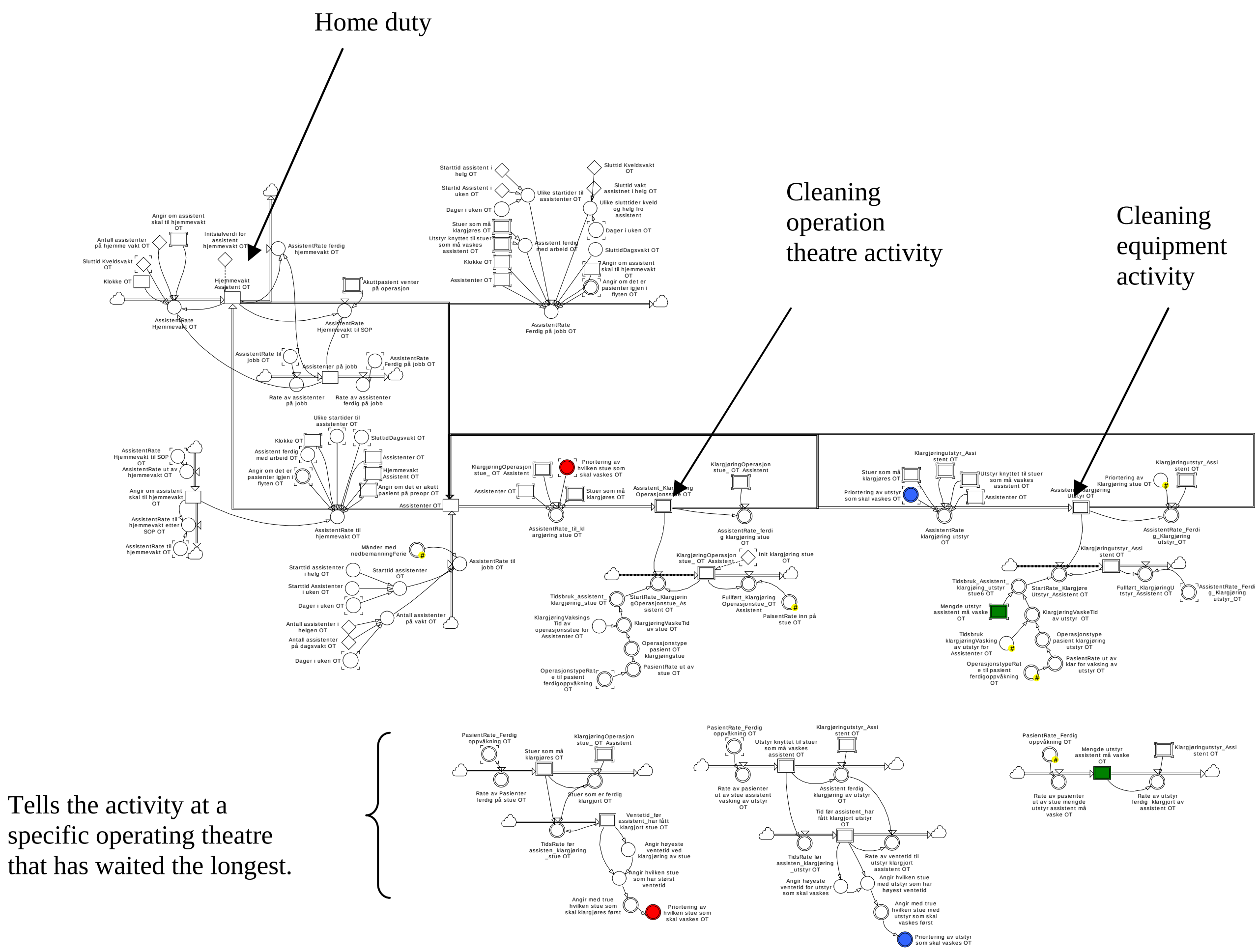


Figure 30: Model over assistants. (The coloured auxiliaries shows the connection to the flows)

3.2.2.5 Surgeon

The surgeon resource is not a part of SOP in the same way as the other resources. They are employed at different departments in the hospital and come to SOP when their patient is ready to be operated. Since the surgeon is not employed or rented in at SOP the surgeon costs are not included in the model. Even though they are not hired or rented by SOP the surgeon is a key element in the patient flow because they are needed to perform the operation. The operation can not start before all of the surgeons are present at the operating theatre.

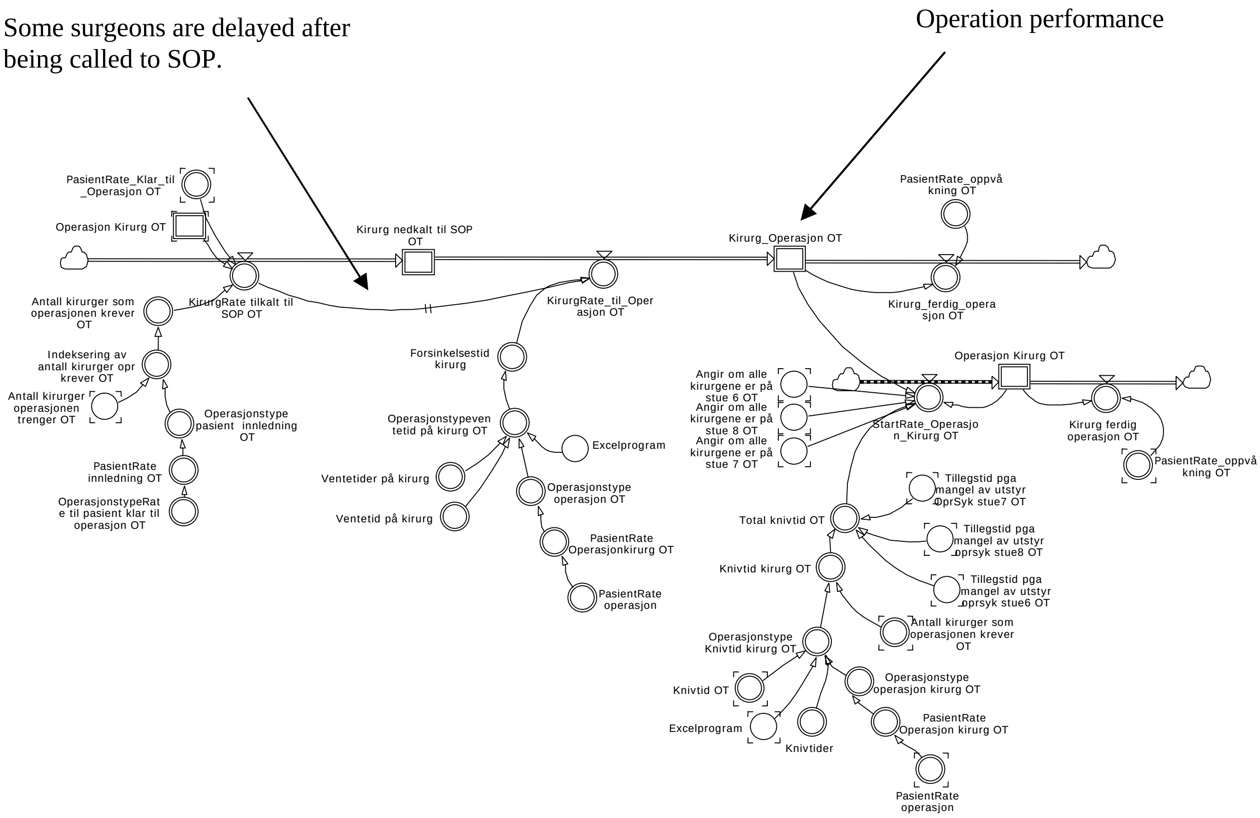


Figure 31: Surgeons participate at the operation at SOP.

3.2.3 Model description in more detail – Time and cost accumulation

Both time and costs are accumulated in the model. The time the different resources spend on activities are accumulated. In those instances where the time can be assigned to a patient and an operation type the time is added to a stock with a range containing all of the operation types. The different activity times are also accumulated making it possible to calculate the average time the different operation takes. The modelling of cost is done equally making it possible to se what an operation costs. To measure effects of different policies it is necessary to have more variables than number of performed operations. The time and cost aspects are important variables in this system to measure effect. The time accumulations can tell whether the patient flow is smoother which can indicate less delays or better utilisation of the resources. The accumulation of the different cost can support these results or in other cases indicate how much the cost might rise if there is an increase in resources.

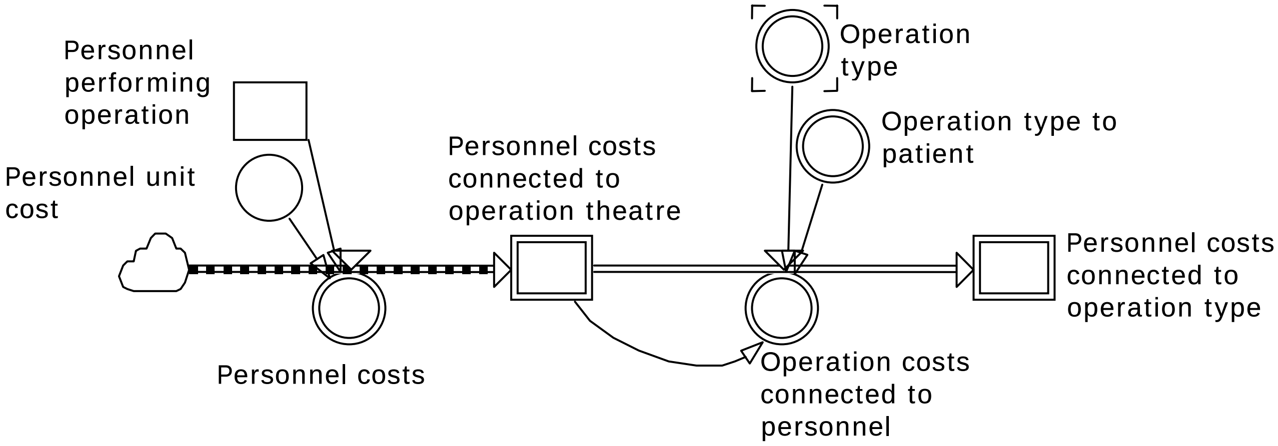


Figure 32: Model over activity cost the personnel.

3.2.4 Model description in more detail – Postoperative division

The postoperative division is not staffed by SOP personnel, but is a part of the complete model because it can limit the number of performed operations. The patient costs at the division are also added to the total operation costs. There are 25 beds at the division which is used by Orthopaedic, General Surgery and Head/Neck sections. Thorax has it own postoperative division that has seven beds. The two postoperative divisions are modelled in the same way by having a vector that indicates the number of beds (see figure 33).

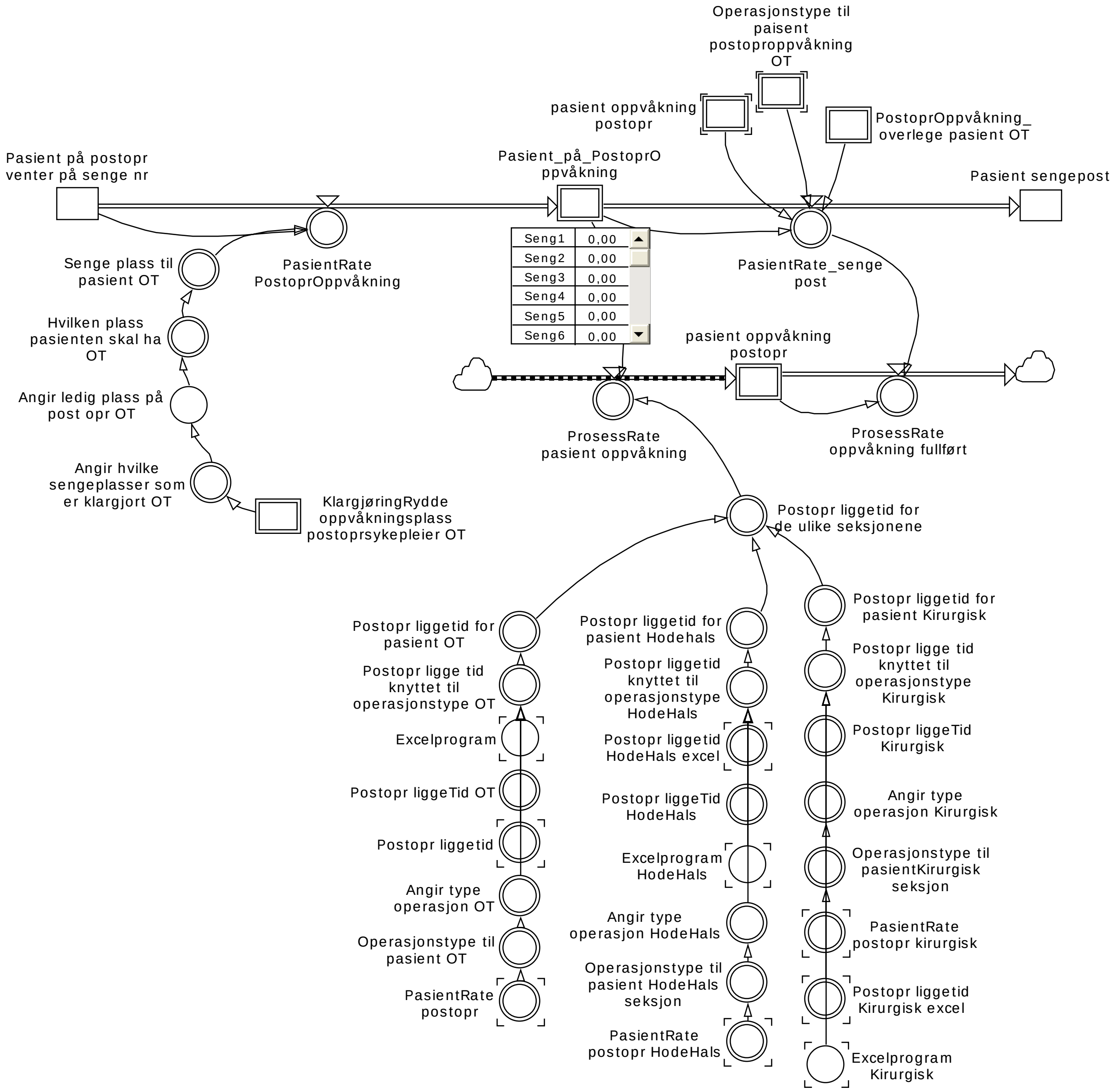


Figure 33: The postoperative division.

The patients are put at the first vacant position and again the operation type of the patients decides the length of stay at the division. After spending time at the recovery the patient flows out of the stock. Before a new patient can take the same position (bed), that the patient had, it needs to be cleaned by the postoperative nurses. The first vacant and cleaned bed is given to the next arriving patient showed in the inflow to the stock named “Pasient på postoprOppvåkning“(see figure 33).

Because of the restricted number of beds at the postoperative division the model needs to make sure that there is a vacant bed for all of the patients going to the division. If the patient needs to stay at the postoperative division after the surgery there has to be a free bed or the operation gets postponed. All of the patients that are going to the division get summed up (see figure below). If there is a free bed for the patient the bed is hold of as the patient flows through the SOP division.

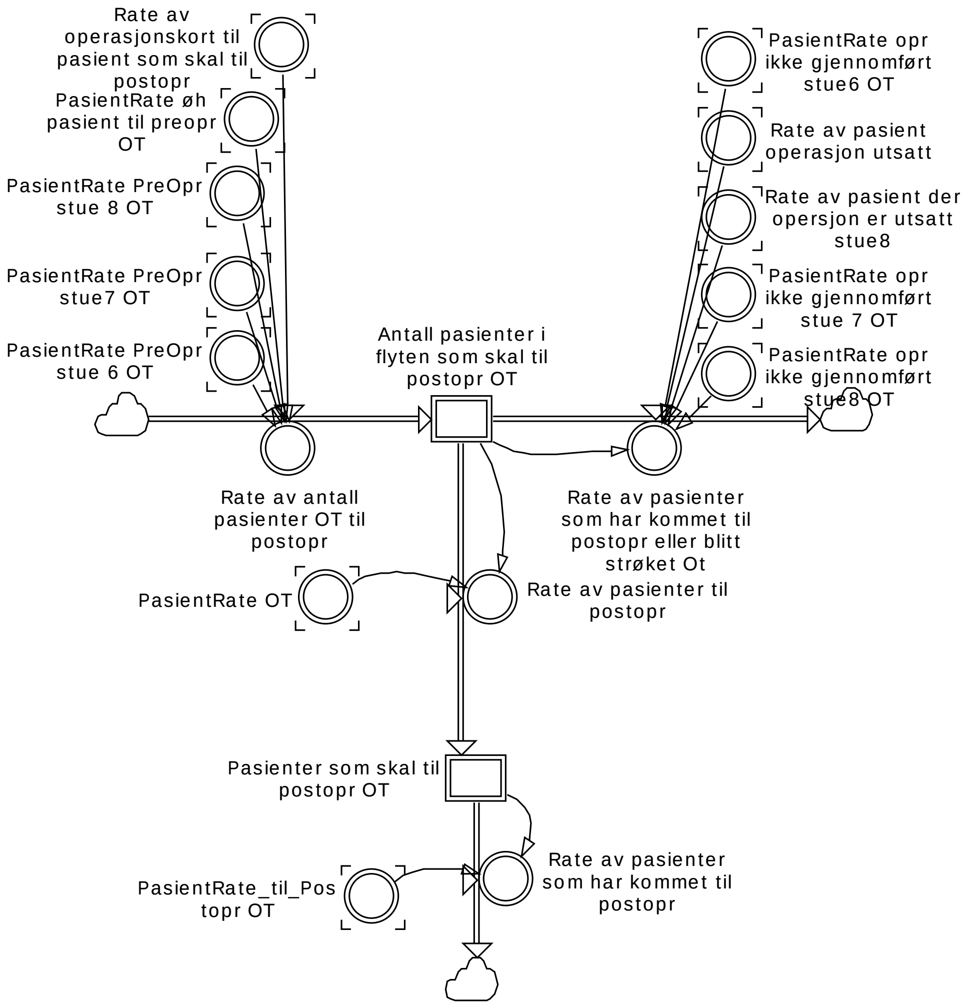


Figure 34: Summing up patients at SOP that needs to go to postoperative.

To number of vacant beds at the postoperative division is calculated subtracting the number of patients at the division and the number of patients at SOP that is going to the division from the total number of beds. Free beds are given to patients that are waiting for an operation and inn need of a bed at the postoperative division. If there are enough bed the “Angir med true hvilken seksjon som har pasienter det er plass til på postopr” states true for the section having patients that are given beds at the division.

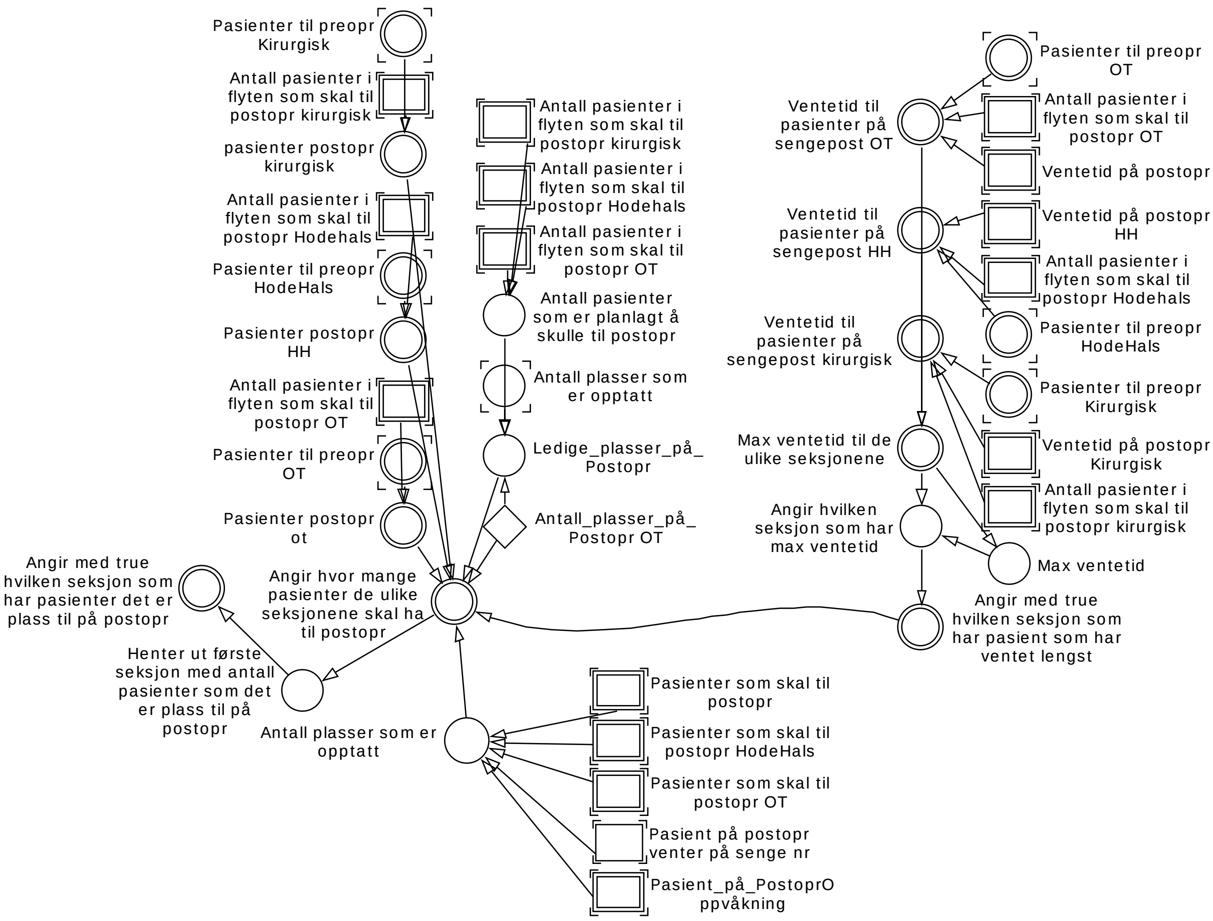


Figure 35: Restrictions connected with the number of beds at the preoperative division.

<u>Angir hvor mange pasienter de ulike seksjonene skal ha til postopr</u>: FOR(p=Seksjoner | IF(NUMERICAL(p) = NUMERICAL(OT);IF(Ledige_plasser_på_Postopr>=0;1;IF('Antall plasser som er opptatt' < 'Antall_plasser_på_Postopr OT' AND ARRSUM('Pasienter postopr ot')>0 AND 'Angir med true hvilken seksjon som har pasient som har ventet lengst'[OT]=TRUE;1;0));IF(NUMERICAL(p)=NUMERICAL(HodeHals); IF(Ledige_plasser_på_Postopr>=0;1;IF('Antall plasser som er opptatt'<'Antall_plasser_på_Postopr OT' AND ARRSUM('Pasienter postopr HH')>0 AND 'Angir med true hvilken seksjon som har pasient som har ventet lengst'[HodeHals]=TRUE;1;0));IF(NUMERICAL(p)=NUMERICAL(Kirurgisk);IF(Ledige_plasser_på _Postopr>=0;1;IF('Antall plasser som er opptatt'<'Antall_plasser_på_Postopr OT' AND ARRSUM('pasienter postopr kirurgisk')>0 AND 'Angir med true hvilken seksjon som har pasient som har ventet lengst'[Kirurgisk]=TRUE;1;0)); 0))))

The postoperative division at Thorax is modelled equally to the other postoperative division apart from the tracking of number of free beds at the division. The calculation of free beds at Thorax is modelled different because there is only one section to consider making the calculation easier.

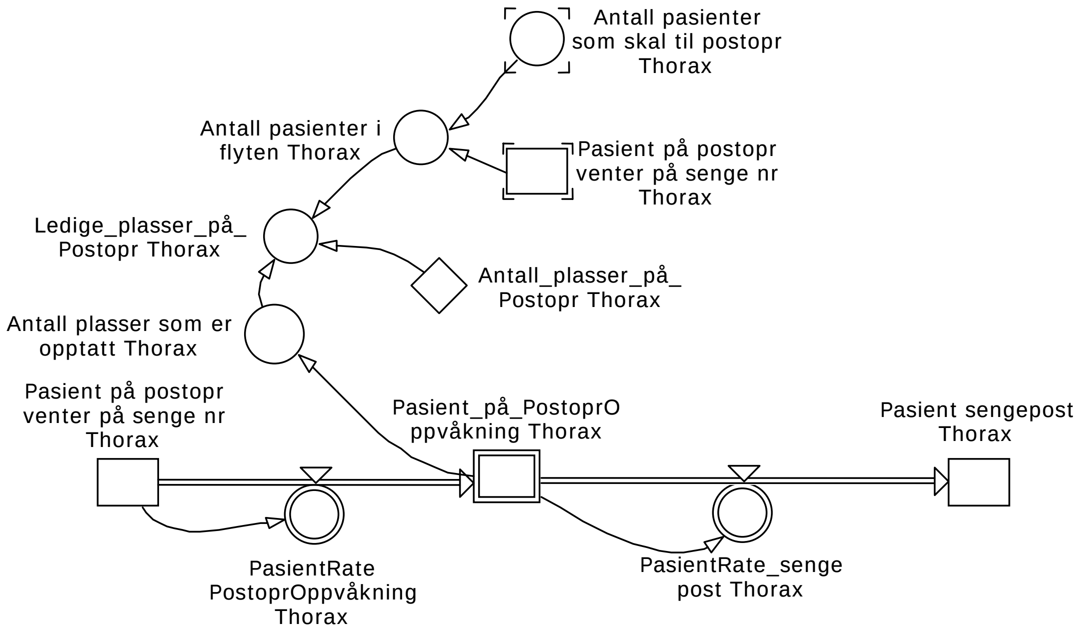


Figure 36: Calculation of free beds at postoperative Thorax

Ledige plasser på Postopr Thorax: 'Antall_plasser_på_Postopr Thorax'-('Antall plasser som er opptatt Thorax'+'Antall pasienter i flyten Thorax')

Recovery nurse

The last personnel group is the nurses at the postoperative division who performs activities like checking reports when patients arrives at the division, overlook the patient during the stay at the division, cleaning beds and writing reports to the bed post. Equally to the other models over the personnel there are constraints at each inflow to an activity performed by the nurses, making sure that the stock of available nurses do not turn negative. Activities involving patients are prioritized first then followed up by the activity that have been postponed the longest.

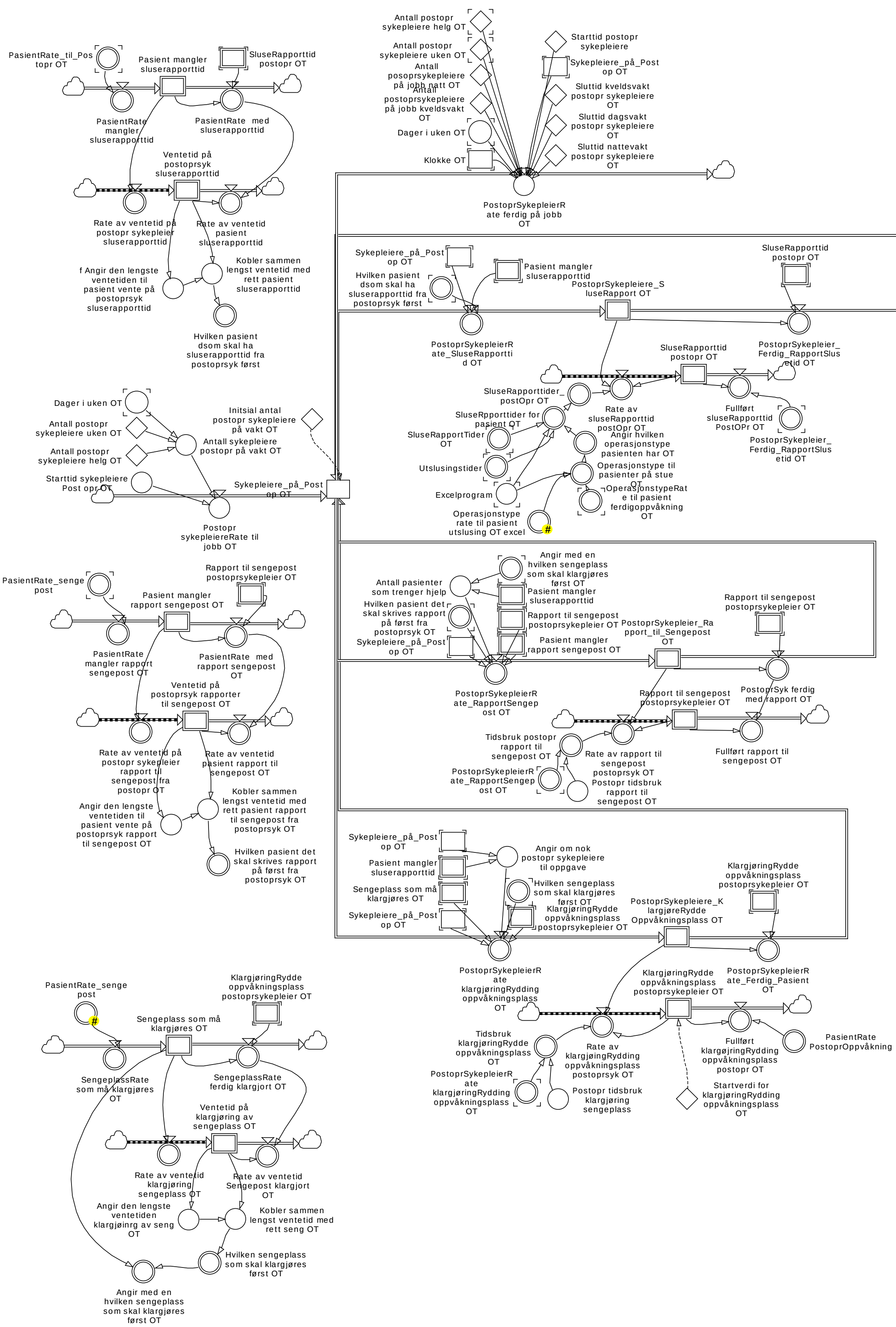


Figure 37: The recovery personnel model.

3.2.5 Differences between the modeled sections

As mentioned, are two of the four sections at SOP modelled in detail. The structure of these models is the same, but the organisation and utilization of the resources at SOP are different. The main differences between the sections are:

- The OT section is the only one that has one operations room exclusively to operate immediate care patients and no elective operations re planed at this theatre. At the other sections the patients in the immediate care line are operated at the first vacant operation room and the planned operations have to wait until the acute operation is finished. All of the different operation room at the other sections have a planed operation program.

- The Thorax section is the only section that does not have shifts at SOP performing operations in the weekend. The personnel at home duty are called inn to perform the operation if acute patients arrive. Thorax is the only section that has its own postoperative division getting a better isolated patient flows while the other sections have to share the beds at the other postoperative division. The Thorax section is also the only section that does not have an elective operation program on Fridays, but only operates immediate care patients this day.

- Thorax and the OT section have an even amount of operation theatres (three each) while Head/Neck and General Surgery have more operation rooms (7 and 6 each). The Head/Neck and General Surgery sections performs operations belonging to several surgical field while OT and Thorax only performs operations within orthopaedic and heart. Not all of the operation rooms at the Head/Neck and General Surgery sections are in use every day of the week and this is incorporated in the model.

Apart from these differences the personnel roles and models over the personnel, the patient and information flow are the equal modelled in all of the different sections.

3.3 Sources and collection of data

The project is based on many different types of information and data like reports, data from the operations systems database and interviews. The reports that have been used are made by the hospital and consider problems at Sentraloperasjonsavdelingen. Some of the reports are from some years ago before SOP was divided into sections but the problems that are mentioned in these reports still apply today.

Some of the data that have been used are based on an ABC- analysis (Activity Based Costing) that has been made over the OT section. The analysis document different activities at the section and distributes the cost on the different activities. The different cost is also divided on the different operation types within each activity. The unit costs in the model have been calculated from data in the ABC-analysis. Some of the percentage time uses of the personnel groups on different activities in the analysis have also been used in the model. Other data that have been collected are data form the database Orbit at Haukeland sykehus. The database consist of information concerning operations of patients like time spent at SOP, planed operation time, type of patient (acute or planned) and so on. After looking at the different possibilities for collecting data from Orbit I made a proposal as to what data that I needed and how I wanted the data set up. The data was given to me in form of an MS Access database and contains information about 87 921 patient treatments.

I have also performed several interviews of personnel at SOP, some of them have been with the section leader at OT and some have been in form of group interview administrated by the consultant company Prosess Partner AS. The interviews with personnel at SOP were in form of open interviews with some questioned made in advance. The focus in the interviews was on the patient flow and resource use. Some of the interviews have resulted into other questions that have been answered by mail. The group interviews were administrated by consultants and had the goal to collect information as to what the group thought functioned well at SOP and which areas there were problems. There was one meeting per section at SOP and one meeting with the leaders at Kirurgisk Service Klinikk.

To construct the model I have used a computerised program called Powersim Constructor and Powersim Studio 2005. I have also used Microsoft Office Access 2003 to make queries in the collected data and Microsoft Office Excel 2003 together with Powersim Studio.

3.4 Calculations of parameters

3.4.1 Calculation of activity times

The different activity times in the model varies form patient to patient and are dependent on the activity being performed and the operation type. The different times are based on data collected from a database that consist of operation data spanning from the year 2000 to 2004. The collected data consisted of all of the different operation types that has been completed and planed, the number of elective and immediate care patients, different degrees to the immediate care patients and the time that the patient has spent at the different activities. The different times where connected to the operation type and are used to calculate the activity times. The random selection of times is similar to Monte Carlo simulation – it is uncertain what activity time the patient will get. For each uncertain variable the possible values within a probability distribution will be used. The type of distribution has been selected based on the condition surrounding the variable. To get the right distribution of the activity times I estimated the arithmetic average and the standard deviation to all of the different times. The times that were collected where not normal distributed. To get this distribution I used Log (Normal) where the normal distribution is calculated:

$$\mathbf{f(x)} = \frac{1}{\sigma\sqrt{2\pi}} \cdot \mathbf{e}^{\frac{-(\mathbf{x}-\mu)^2}{2\sigma^2}}$$

where μ is the arithmetical average and σ is the standard deviation. This gave the right distribution of the times compared to the data that was collected.

There where two activity times that where not found in the dataset and had to be calculated out of other times. The time spent on locking in and out patients where in the dataset from the database included in the preparation of the patient at SOP and the finishing of the operation. I therefore had to use average times, found in the ABC analyses, for these activities. To get the right preparation and finalization times I took the preparation time minus the time spent at locking the patient inn and the time spend on the finishing of the patient minus the time spend on locking out the patient. These calculations can lead to wrong times spend at the different activities but considering the data that where available I have not seen another way to calculate these times. The data set also contained errors which where discovered when calculating the missing times. These where removed to avoid errors in the used data.

In the collected data there is no record over the length to different added time delays like how long it takes before a missing journal arrives at SOP or the time it takes to replace lost equipment or how much of the registered time is spent on waiting for personnel. This is a weakness in the time calculations in the model but unavoidable considering that the registration of the different time delays does not exist in the databases at the hospital. This makes the time use in the model bigger then in the real world because delays are added to times which already might consist of delays. To minimize the incorrectness in the time data a parameter adjustment has been performed (see validation chapter)

Data on how much time personnel spend at one activity turned out to not be registered in the data from the hospital. The time that different personnel group spend on some activities had therefore to be calculated out from the ABC-analysis. This also had to be used at instances where not all of the personnel are part of the whole activity. The personnel had in the ABC-analysis given a percentage of how much of their day they spend on the different activities which has been used to calculate some of the different activity times. This is also a weakness in the time calculations and might have an impact on the results and must therefore be considered in the policy testing and also in the validation of the model.

3.4.2 Calculation of costs

As described before, cost is an important variable when modelling patient flow. The different unit costs are based on an ABC-Analysis, made by the hospital, which considers the OT section (Helse Bergen, 2003 a). In the ABC-Analysis the total cost for 2004 for each of the different personnel groups has been set. The unit costs for the different personnel groups and roles have been calculated using the number of man-labour year and the number of hours in a man-labour years. The cost has been broken down to cost pr minute because the time step in the model is one minute making it easier to accumulate the cost of the personnel use pr activity. Since there has not been done equally analysis of Thorax the cost parameters are set to be equal to those calculated for the OT section.

Some cost is not connected to personnel use but use of other resources like use of operation room or beds at the postoperative division. The total costs from the use of these resources in 2004 have been divided on the total time use of the resources giving a cost pr minute.

3.4.3 The calculation of acute frequency

There is no structure over when immediate care patients arrive at the hospital. They come at different times during the day or night and the number of patients also varies. The degree that each patient gets, gives the length they can wait before getting surgery, also varies. To generate these data in the model, making patient arrive at different times and days, I used data form 2004. The immediate care patients that arrived where divided into acute (degree less than 8 hours) and those that could wait longer. The day of the week and the number of patients that arrived at the hospital was also collected. The time of the day that the different patients arrive are also important so the day was divided into seven time intervals each consisting of three hours meaning that the patients that arrived between the time 00:00 and 03:00 are put into the same interval and so on. The number of patients that was put into the same interval was summed up. Amount pr day and the frequency every third hour became variables in the model. To get the right frequency of patient's theses calculations where used in the model:

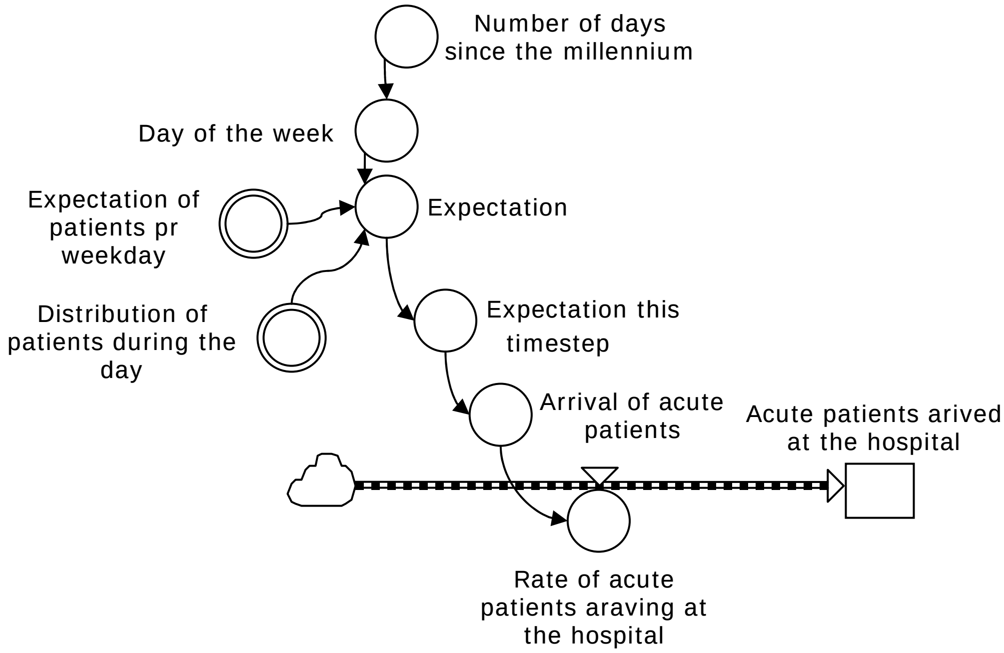


Figure 38: Model over acute patient's arrival at the hospital.

<u>*Number of days since the millennium*</u>: (DATE (YEAR ();MONTH(); DAY())-DATE (2000)) /1 <<da>>

<u>*Day of the week*</u>: INTEGER(('Number of days since the millennium'+5) MOD 7 + 1)

<u>*Expectation*</u>: 'Distribution of patients during the day' [INDEX(1 +INTEGER (HOUR()/3))]* 'Expectation of patients pr weekday' [INDEX('Day of the week')]/3<<hr>>

<u>*Expectation this timestep*</u>: Expectation*TIMESTEP

<u>*Arrival of acute patients*</u>: RANDOM (0;1;0,382)<'Expectation this timestep'

Day of the week indicates what day it is with numbers form 1 to 7 where one is Monday. The variable "Expectation of patients pr weekday" is the distribution of patients that have arrived the different days in the week, and "Distribution of patients during the day" is the distribution of patients during the day divided into periods on three hours. The "Expectation" variable is the number of patients pr day times the distribution of patients pr day during the given hour. These calculations gives the right amount of patients and make them arrive at different times similar to the behaviour in the real world.

3.4.4 Distribution of degree of urgency

The immediate care patients arriving at the hospital get a degree of urgency. The degree varies after how acute the patient situation is. Data collected from ORBIT was used in the model to get the right distribution of the degrees given to the patients, “Different acute degrees”, and right the number of patients getting the different degrees, “Number of patients within a degree”, (see figure 39). To get the right number of patients within a degree the cumulative sum of the number of patients with in a degree was divided with the total number of patients. Then to set the right distribution the Random function was used giving numbers between 0 and 1 (Random selection) and Scangt function which goes through a vector and gets the first count element in the vector that is greater then the number given by the random function. This means that if most patients have a 24 hour degree there will be a big leap of values between the degrees less than 24 hours. The 24 hour degree will therefore be picked out more often than the other degrees. This means that the distributions of degrees in the model are based on how often the degree is given to a patient.

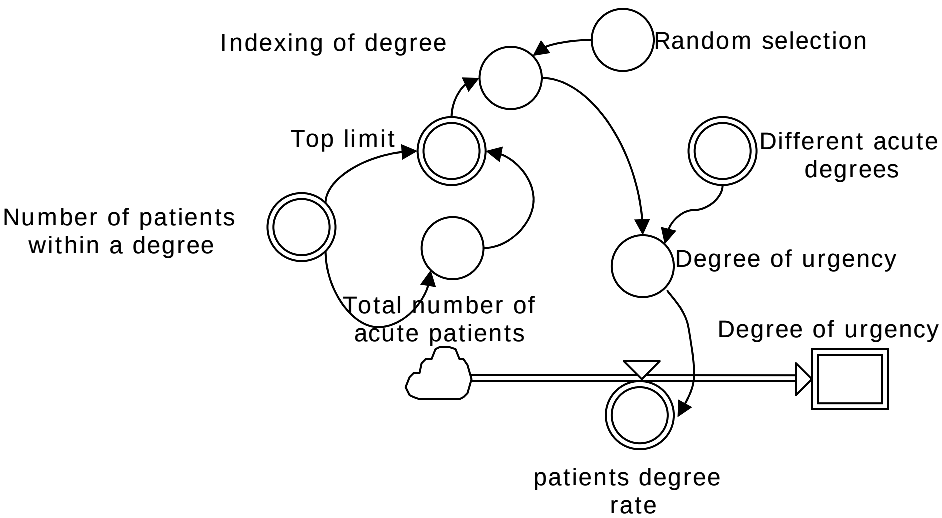


Figure 39: Model over the distribution of degrees.

Indexing of degree: SCANGT('Top limit'; 'Random selecion')

Degree of urgency: ('Different acute degrees'[INDEX('Indexing of degree')])*60

Total number of acute patients: ARRSUM('Number of patients within a degree')

Top limit: CUMULATIVESUM('Number of patients within a degree')/'Total number of acute patients'

Indexing of degree: SCANGT('Top limit'; 'Random selecion')

The data from Orbit did have some shortage in the patient data from the Thorax section. In many instances there was a lack of urgency degree and arrival time for immediate care patients. This made it more difficult to calculate these variables and can lead to a wrong distribution of immediate care patients at this section.

3.4.5 Operation type

All of the operation types that have been performed at the different sections are elements in a range at each section. The operation types consist not only of operations that are typical for that specific section but of all operations that has been performed at the section. The amount of different operation types are based on total number of performed operation in 2004. The different percentage of patients within an operation type that went to postoperative division in 2004 are used to make sure that the amount that goes to the division does not exceed the real percentage. This makes sure that if the postoperative division diminishes the patient flow this would not be because of errors in the amount of patients.

Number of operation types

M4ReseksjonAvMamma	0,00
NkLumbalDekompresjon	0,00
OrtoRyggmetastaseBakreTilgang	1,00
OrtoRyggmetastaseFremreTilgang	0,00
OrtoAchillesseneForlengelse	1,00
OrtoAchillesseneforlengelseOgBakreKapsulotomIA	0,00
OrtoAchillesseneruptur	0,00
OrtoACLeddluksasjonPinningOgCerclage	0,00
OrtoAlbueÅpenKortvarigOperasjon	6,00
OrtoAlbueÅpenRekonstruksjon	0,00
OrtoAlbueAtroskopi	9,00
OrtoAlbueluksasjon	0,00
OrtoAmputasjonLeggKne	1,00
OrtoAmputasjonLårHofte	1,00
OrtoAmputasjonTå	1,00
OrtoAnkelArtrodeseArtroskopisk	0,00
OrtoAnkelArtrodeseÅpenOperasjon	3,00
OrtoAnkelArtroskopiskeInngrep	21,00
OrtoAnkelÅpenOperasjon	6,00
OrtoArtrodese	6,00

Figure 40: Number of and different operation types connected to one section at SOP.

3.5 The modeling process (assumptions and problems)

This chapter will give a short presentation of the modelling process and of some of the problems encountered in the development of the model. The modelling process has been a long and challenging process. The project was initiated by the hospital making it important to build a beginning model fast to assure that the hospital could see a potential in the project. I therefore started out building a model out of descriptions from reports. Knowing very little about the hospital and nothing about SOP the beginning model was not good. The model consisted of the Orthopaedic section at a high level with little detail. It became evident that to be able to capture important elements affecting the patient flow more details had to be included concerning resources and the steps of the patient flow leading to the complete and complex modelled already explained.

The beginning model consisted of a patient flow and a flow of personnel that was a co-flow to the patient flow. The patient flow was driven by the different times that the activities took. After working with the starting model I had interviews with personnel at SOP and got a lot of information and an understanding that things where much more complicated than what I had assumed. The first change that was made was to divide the different personnel tasks making it not a co- flow to the patient flow and connecting a “performance level” to each of the activities performed by the personnel (see figure 4). The performance level have a stating value of zero indicating that the personnel, performing the activity, have not yet started on the task. As the personnel performs an activity the level rises form zero to one indicates that the personnel has finished his or hers task. The performance levels make the personnel be what makes a patient flow through SOP, similar to the real world. The solution also makes it easier to assure that every personnel group had performed their task before the patient could flow to the next activity.

The different personnel group was modelled separately and after splitting up the different activities and making the performance level the challenge became putting all the different personnel models together making them function together and with the patient flow. This was a difficult step in the modelling process. The biggest problem was making sure all of the different groups attended the same patient at the same time, which was difficult because they do not perform all of the same activities. Assumptions were modelled as to which activities the different personnel groups had to prioritize in the different situations. This was a long and complex process for each thing that was changed in the model I had to run a lot of test to correct errors that occurred. A lot of time went into avoiding negative values in the different models of the personnel groups. The different groups have many activities that they need to perform and might bee needed at several activities at the same time. To avoid negative values and to make sure all of the activities where performed in the right order priorities where modelled. The priorities where connected to the inflow of each stock that represented performance of an activity. Activities that include patients are prioritized and the different operation teams prioritize their patients before helping other teams. If this means more then one activity the activity that leads to the fastest flow of patients is prioritized, or if a personnel group have more than one patient to care for the patient that have waited the longest get prioritized. Because of the complexity of the model and the fact that so many different things could occur at the same time I had to run many test to make sure that values did not go negative.

3.5.1 Problems related to the information flow

After making changes to the patient flow and the structure of the personnel groups I started working on the information flows. In the beginning model the times where changed randomly for every new patient that arrived at SOP. By using a SAMPLEIF function the different times where kept until a new patient arrived. This was a good start but it was not good enough because the different operation types where not considered making it not true to the real world. To take into account the operation type an information flow where modelled keeping track of the patient's operation type. The initial idea was to have an information flow where the operation type was visual. This was modelled with a two dimensional array with operation type and operation room. In the information flow the type of operation that the patient had would get the value one as illustrated in the figure below.

Operation type to patient under operation

	OrtoAchillesseneruptur	OrtoBarneortopedisk inr	OrtoBehandlingAvSkade	OrtoBimalleolarFraktur	OrtoFCFOImed	OrtoGlideskruePlateHCS
Stue6	0,00	0,00	0,00	0,00	0,00	1,00
Stue7	0,00	0,00	0,00	0,00	0,00	1,00
Stue8	0,00	0,00	0,00	0,00	0,00	0,00

Figure 41: Illustration of a small part of the initial information flow structure.

This made it possible in the model to see what operation type the patient had. When presenting the model to the hospital this could be an important element to build up the models credibility letting them easily recognising known elements in their everyday life. Although it was a good solution in a test model with few operation types it turned out to be a problem in a bigger model. The array solution increased the models running time making the simulations extremely slow and having over a hundred operation types the visual impression became less then in the smaller model. The different operation types where therefore given a unique number that flows in the information flow making it possible to identify the different operation types and connecting the right operation type to the right patient in the patient flow.

3.5.2 Information collection

I experienced some problems gathering data from the different databases that contained data concerning SOP. I was not allowed to do this myself and the process of getting the data was long. This complicated the modelling process because I had to rely on the information that had been given to me from people that I had interviewed. When I finely got the data I understood that the model was on a much more detailed level then the data. Several elements that could be registered in the operation database had not been entered. This made it difficult and I had to use data from the ABC analysis and combined these with the data from the database.

Working with this project I have also had to change the computerised modelling program I used from an earlier version to a much newer version. This also caused some difficulties making it necessary for me to go through all for the equations in the model and correcting them based on the new versions function description.

4 Model validation

Assessing a system dynamic model involves performing validation tests to assess the models usability and confirm appropriately set boundaries. The main purpose of validation is to build confidence in the model among its users. The focus of the validation, in this study, will be on the models structure, assuring it is adequate with respect to the models purpose. Other areas that will be assessed are the model's boundary, time horizon, and level of aggregation. System dynamics models are often discarded if relationships in the model conflicts with relationships in the real system. Therefore, validation of these models primarily means validation of the internal structure of the model and not its output behaviour (Barlas, 1996). Sterman proclaims that these elements needs to be considered in light of their purpose and those factors relevant to the purpose must be captured endogenously (Sterman, 2000).

System dynamics models are often discarded if relationships in the model conflicts with relationships as observed in the real system. In addition, the process of validation relies on behaviour representation tests. Various tests have been applied to ensure that the model satisfies the criteria for behaviour validity.

Sterman states that model testing should "…be designed to uncover errors so you and your clients can understand the model's limitations, improve it and ultimately use the best available model to assist in important decisions" (Sterman, 2000). When validating the model structure the model behaviour may be used as an indicator of structure validity. In this study, a variety of tests has been conducted to ensure that the models behaviour imitates real world behaviour in a reflection of the fact that the model structure appropriately represents the systems structure. The validation of the model structure has been conducted by repeatedly analyzing the direct structure information, the data reflecting parameter values and the historic development with respect to structural completeness, coherence, and consistency. Among other tests applied are extreme conditions and stock value consistency (that no stocks take negative values).

4.1 Structure validation

Both in theory and in practice, due to the shortcomings of the time series, a behaviour test alone cannot be used to validate the model. The structure test is therefore an important element in the validation process of this model. Barlas states that the “the ultimate objective of system dynamics model validation is to establish the validity of the structure of the model” (Barlas, 1996:188). The models ability to reproduce behaviour of real behaviour is also important but it is only meaningful if one “already have sufficient confidence in the structure of the model” (Barlas, 1996:188). The structural validation is a comparison of the model against the real world, element by element, to investigate whether the model is consistent with our current knowledge about the real system with respect to the purpose of the model. I have, consequently, on an ongoing basis, compared the model with the structural information made available to me through interviews and reports. This has lead to the identification of a number of model shortcomings.

4.1.1 Structure assessment test

The model of SOP is complex and detailed, yet does have its shortcomings when compared to the reality it is intended to portray. Most of the assumptions represented in the model are based on collected information, yet a few assumptions have been introduced by me as part of the modelling process to simplify the process. It is not expected that this changes the policy conclusions of the model. In setting the model boundary, I have been guided by the problems at SOP. This chapter outlines in what respect the model differ from SOP proper. Moreover, in some cases, we refer to a sensitivity analysis conducted to assess the significance of these assumptions and simplifications.

The overall model structure has been presented to employees at KSK, members of the Helse Bergen leadership and others who have taken interest in our work at the hospital. In the modelling process feedback from these meetings has been important to assure the structural correctness of the model and to confirm that the models behaviour is consistent with real life. When building the models structure I have performed extensive compartments with gathered information from interviews and reports to assure that the structure of the model can replicate the real world to an extent needed to perform the policy tests.

Patient preparation

The preparations of patients at SOP are performed at two locations; at the preparation room and in the operating theatre. Initially, I did not distinguish between the two locations in the model and focused merely on the activity itself and not the location where it was performed. Not all of the personnel participating in the preparation at the preparation room, however, continue the preparation at the operation theatre. This lead to a need to distinguish what goes on where. Also, if these activities were not distinguished, the model would not realistically represent the waiting time for a clean operation theatre. Since such waiting times may be significant, causing obstructions in the patient flow and, potentially, delaying preparation completion and operation start in was decided to divide the preparation into two activities.

It turned out that the distinction between preparations taking place outside and inside the operating theatres, respectively, was not readily present in the data available. Consequently, we based ourselves on information from the ABC-analysis. With respect to one particular personnel group there are some uncertainties concerning this partitioning of work, leading to a need for further sensitivity testing (see Sensitivity analysis chapter 4.4).

Calling patients to SOP

Modelling human decisions such as calling a patient to SOP became challenging. The in-flow to SOP is restrained by many factors that are judged differently by various decision makers. The outcome is influenced by the experience of this personnel and their ability to foresee what will happen. Factors considered when calling a patient are the operation in progress, the remaining time of the shift, changeover times, personnel accessibility, vacant beds at postoperative division etc.. To keep the changing time (the time it takes from one patient leaving the operation theatre to the arrival of next patient) small to prevent waiting times, the personnel assesses the remaining time required to complete the treatment of the patient currently at SOP when calling on the next patient.

In the model, we address this issue by using accumulated time spent and time we expect will be spent by a particular patient as a proxy for the factors actually used by the personnel when making a decision to call a patient down for surgery. The implication is that the expected times, consequently, do not always correspond to the actual time that the patient spends at SOP. Delays in the system can contribute to a longer stay and feedback from the prolonged stay leads to delays in other activities and for other patients. Estimating the total time spent with a 100 % accuracy is, even in the real world, extremely challenging. I consequently assess the proxy we have used as an acceptable approximation of the way judgements and calls are being made.

Lunch

Lunch is a daily activity that significantly impacts the program in that it contributes to a reduction of resources available. In the model, as in reality, there are some constraints regarding the lunch activity. During lunch, some human resources typically have to be replaced by others, meaning they can not go for lunch before their replacement is available. Because of flexibility restrains in the model, and due to the need for a replacement, it occurs that not all of the personnel may go for lunch. Although this also actually happens, the consequence of this limitation is tested in the sensitivity analysis, to find out the significant of the lunching activity in the model.

Physical layout of preparation rooms vs. activity performance

The physical layout and limitations of the SOP are, for the most part, addressed in the model, - except for one particular constraint concerning the preparation room. A preparation room is shared between two operating theatres and there can only be one patient at the time in the room. For several reasons this limitation is not represented in the model. No problems have been identified with reference to this constraint, - in part due to the fact that patients, for which there are no preparation rooms available, are brought directly into the operating theatres. This, for the most part, happens in the morning when the theatres are available for such preparations. Later in the day the competition for preparation rooms is less due to the phasing of the incoming patients. Moreover, typically other constraints, such as the availability of anaesthesia nurses, govern the systems performance.

Prioritizing

Regularly, situations arise at SOP where personnel are needed to conduct several activities simultaneously. When the need for simultaneous processes arises in the model, priorities determine which activities are undertaken and patients are attended to first. The various priorities take effect when the structure of the system or the resource can only handle one activity at the same time. The time a patient or activity has waited decides the order of priority. The priorities implemented in the model is based upon extensive interviews of the personnel involved so as to reflect their considerations and assure that no negative values appears in the patient or personnel stocks.

Team connection and shifts

Each operation team, in the model, is associated with a single operation theatre. Although the model allows for personnel to assist other teams this flexibility is constrained compared to what happens in reality. Actually SOP does substitute for team members during brakes and help out when others are occupied. This is to a big degree considered in the model like a nurse replacing another during lunch or the middle watch preparing a patient if a nurse is occupied. But a “five minute” brake is not considered in the model. The personnel in the model do only have brakes, a part from lunch, when there are no patients at SOP and all of their tasks are completed.

In the model, the personnel are only assigned roles. They are not individualized, such as the patients and are not distinguished in terms of education, experience or other characteristics. A shift in surgical teams takes place when the evening/nightshift relives the dayshifts. Since the teams are not distinguished in terms of individuals, team shifts are implemented simply by prolonging the dayshift making into an evening shift. There has not been pointed out any problems regarding the shifting of teams and it does not hinder or cause any limitations in the patient flow because the SOP team shifts are conducted is performed efficiently and flawlessly. The reduction of the number of teams, however, from the day to the evening shift is explicitly represented in the model and has been identified out as a problem at SOP. We will address this as part of the policy analysis.

Surgical program

The planning of the surgical program is not carried out by the personnel at SOP and they have little influence on the planning process. The modelling of the operation program (explained in chapter 3.2.1.1) is constructed without considering the operation type. The composition of the program is in the model govern by the operation types planed séance time which is also a factor when the different day programs is planed, but other factors that contribute to the planning of the program is not considered. I have no medical education and can therefore not make assumptions as to which composition of different operation types that is best. The choosing of which operation type that is planed together is at times controlled by the experience and field of expertise to the available surgeon.

4.2 Parameter adjustment

The level of aggregation detail that we chosen for the model defines the need for fidelity in the data we use for validation purposes. The data collected at the hospital for the purpose of this study was extensive, yet impaired by some shortcomings arising from the fact that data at the level of detail characterizing the model in some cases are not available. In particular, it has been difficult, to obtain data from ORBIT that splits the different activity times into actual performance time (that involves personnel undertaking an activity) and delay times (that involves a waiting patient, and, commonly, waiting personnel). Moreover, some of the personnel are not present throughout an entire procedure. In those cases, the ABC-analysis was used to provide a breakdown of the time fractions various resources spent to complete a procedure. There has also been a need to subtract some activity times from other activity times because the needed time was included in other activity times (see chapter 3.4.1 Calculation of activity times). These shortcomings in the data times lead to a need for adjustments of the times that resources spent at the activity (performance times).

The parameter adjustments where carried out by comparing simulation results to empirical data. The aim was to get the amount of the total activity times that was due to delays arising within the system. Through using activity times from empirical data, in the base model, and by running the model delay times would be added to the empirical activity times. The resulting activity times makes it possible to asses how much of the activity time that is due to delays and how much that is actually performance time. By reducing the empirical activity times with the delay times produced by the model the performance times used in the base model would be more equal to the actual performance times.

The base model was used as a point of departure with the surgical program of 2004, meaning the same surgery types performed in 2004, where run in the model. To perform the parameter adjustment I have used the empirical activity times from 2004 as input times to the different activities in the model - giving the time span an activity is to be performed in. The empirical data consists of activity times, from ORBIT for all of the performed surgeries in 2004, and activity times from the ABC-analyses. Most of the activity times are connected to a specific operation type (see chapter 3.4.1 Calculation of activity times) and, in this test, to the same patient as in 2004. The operation program in the model, used in the parameter adjustment, is composed by the same operation types performed in 2004. The different surgery programs are given to the surgery theatre where the program was performed in 2004. By giving the motioned data as inputs to the model it will reconstruct the same patient flow as performed in 2004. The year 2004 was chosen for this parameter adjustment because the ABC-analysis is based on the year 2004. The model was run for one year.

When running the model, the time patients spent at the activities was accumulated for each activity. The empirical times for the different activities was also accumulated for each patient. The figures below show the total activity times produced in the model and the total accumulated empirical activity times at the OT and Thorax section (figure 42).

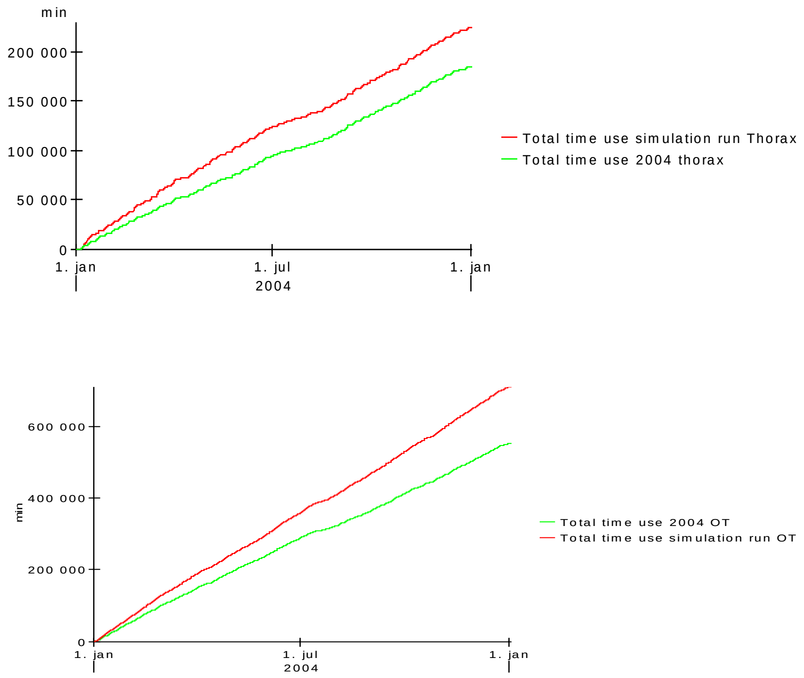


Figure 42: Compares the simulation results from sections with personnel against the actual data.

The parameter adjustment is only needed at those sections with personnel models. It is only at these sections there is produced delay time by the system. The figure 42 show that there is a discrepancy between the two total times leading to a need for an adjustment of the parameters. The total activity time (produced by the model) at each activity and for all of the performed surgeries where compared to the total empirical time for the specific activity. The discrepancy between the two total times where calculated, giving the needed percentage reduction (delay time) of the times connected to the activity (table 2). The different percentage reduction was subtracted from the activity times giving now the performance time for the different personnel groups for the different activities.

Activity	**Locking in**	**Pre - preparation**	**Operation**	**Finalization**	**Locking-out**
OT	10 %	25 %	0 %	23 %	50 %
Thorax	3 %	12 %	0 %	5 %	13 %

Table 2: Parameter adjustment

Differences between the OT and Thorax sections need for reductions of the parameters are caused by number of patients and their composition, amount of available resources and shortcomings in the data basis. The total locking out activity time needed the biggest adjustment. The time it takes to lock a patient out is collected from the ABC-analysis because it was not possible to separate this time from the activity time that it was registered as a part of in the ORBIT data set (explained in chapter 3.4.1 Calculation). This, together with the percentage times that had to be used for the different personnel groups participating in the locking out activity, lead to a need for a bigger reduction of the times so that it would match the empirical data better.

An ideal situation would have been to have all of the needed data at the right level of detail or a model at the same level of detail as the data diminishing the need to adjust parameters. In the case of this thesis it would have meant a reduction of details in the model leaving out important elements. I have therefore focused more on the model structure and the similarity between the model's behaviour and the real world to strengthen its usability compared to its purpose.

4.3 Behaviour reproduction and extreme conditions

Behaviour reproduction tests assess a models ability to reproduce the behaviour of the system and the model boundary. Extreme condition tests are, addition to testing the models robustness in extreme condition, also a part of the behaviour test and tests the models ability to not violate common sense. Validating the models structure and composition has also been done through behaviour tests.

4.3.1 Behaviour reproduction tests

In the analysis, the model structure has been tested through a series of behaviour tests. Only after having established that the structure of the model reproduced the systems behaviour for the right reasons (i.e. because the underlying model structure represents that of the system) can one establish that the model is a suitable vehicle for policy evaluations. The behaviour reproduction tests consist of assessing the models ability to reproduce the behaviour exhibited by the system modelled. The tests that have been performed compares the patient flow, the activity performance of the personnel and the surgical program completed at SOP in 2004 with the model representation of these factors. The base model (described in chapter 3) has been used in the performance of the different behaviour tests.

Detail structure oriented behaviour test

Throughout the modelling process I have undertaken validation activities. The various model components (patient flow, resources, postoperative ward etc.) have first been validated individually and subsequently as part of larger model components – assuring that the model produces the right behaviour and for the right reasons, i.e. because its structure corresponds to reality. To assure that the model structure is correct and that the different model elements are correct assembled I have though out the entire modelling process validated the model's behaviour and structure up against gathered information. The model's produced behaviour and element structure are tightly connected - one error in the structure leads to a wrong produced model behaviour. I have therefore analysed the models behaviour to uncover errors in the structure of the model.

The starting model consisted of the patient flow controlled by the empirical activity times which determined the length a patient was to be at an activity (see chapter 3.5 The modeling process (assumptions and problems)). The behaviour results produced by running the starting model where validated to make sure that the patient flowed through the different activities in a correct manner. The figure below exhibits a patient flowing through SOP as reproduced by the model when having the input of one patient in the model.

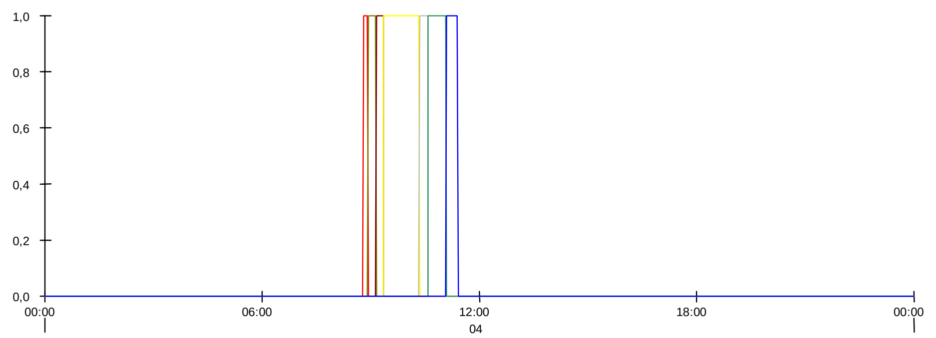


Figure 43: Patient flow through SOP

The various lines represent a patient's presence at different activities and the distance between the lines the length of time the patient spent at the activity. The red line in the figure illustrates the locking-in activity followed by the preparation at the preparation room and at the operation theatre (brown colour). The yellow line gives the time the patient spent at the operation and the next lines are the finishing of the operation, wait for a free lock and getting locked into the postoperative division. The different activities are performed in the right order and are interconnected; there is no brake between the different activities. If there are delays the patients stays at one activity equally to real life.

After validating the patient flow one personnel model where connected to the patient flow. The different flow activities that involved the modelled resource where now determined by the performance of the activity by the resource – the patient did not flow to the next activity before the resource had finished performing the activity (the performance level have reached the value of one (se chapter 3.2 Model description)). The patient flow where then validated together with the personnel model - assuring that they interconnected in a right matter and produced the correct behaviour. The similarity between the orders of activities, illustrated in the figures 43 and 44, illustrates the connection between the personnel and patient model parts.

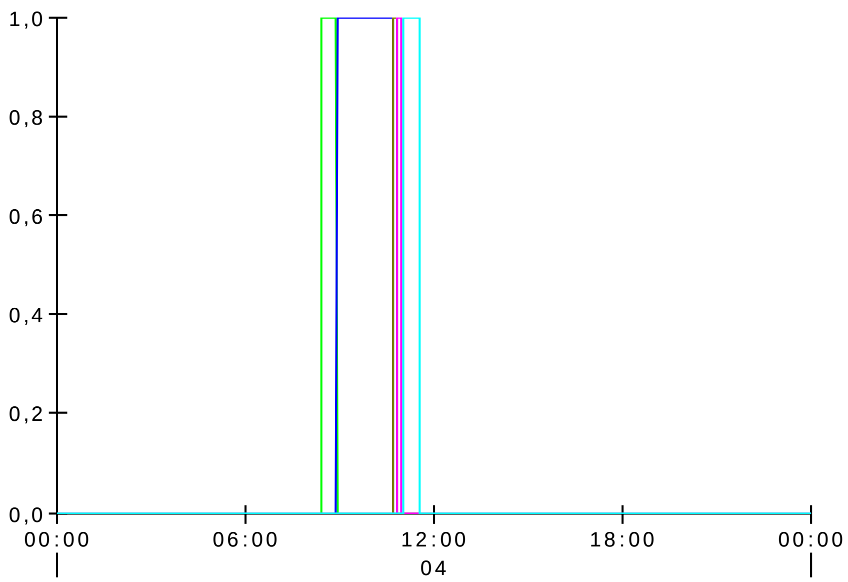


Figure 44: Order of personnel performance of activities – operation nurse

The green line represents an operation nurse performing the preparation of a patient at SOP and the blue line the operation participation. The operations nurse also performs parts of the finalization and the locking out activity (pink line). The last line illustrates the nurse having lunch – performing the lunch activity. The activity is not connected to the patient flow but reduced the nurse availability for the patients in the flow.

When the two model parts functioned in a correct manner another personnel model was connected to the patient flow. The new addition to the model was validated and adjusted so that the total model would give a correct behaviour when run. Elements causing errors in the behaviour where corrected and the model was run and validated again. This procedure where repeated until all of the different personnel models where connected to the patient flow. After modelling the OT section the other sections where added one by one and the model was run for each addition to asses the model’s behaviour. To achieve one behaviour pattern only one patient where allowed to flow through the model during the structure validation. The behaviour pattern would then make it easy to uncover errors and reasons to errors in the model. Adding a new personnel model to the main model have in most cases lead to a need for modelling additional prioritizes. The prioritizes are needed to assure that the different resources treat the patients in the flow together. This avoids having a resource performing an activity and waiting for another resource to finish and that the awaited resource is performing a different activity waiting for the first resource. If this occurs, the patient flow in the model would stop and the different activity times, overtime and cost would be extremely high and not have any foundation in reality. It is therefore necessary to further test the model to asses its ability to reproduce real behaviour.

Running the operation program for 2004

The former test illustrated correctness of the model structure. But even though the model can give a correct behaviour with a small input of patients it is important to validate the model’s behaviour against empirical data. The behaviour produced by the model with empirical data as input can uncover weaknesses or errors in the model that have not been discovered in the former behaviour test. The different model parts can for instance be correct, but the total model, with a bigger input of patients, can have problems with recreating empirical behaviour. A reason for this is that the different model parts can respond differently to the behaviour created in the model. The different model parts creates behaviour that the rest of the model has to consider (as explained about the prioritizes in the former test). There are also limitations in the model like number of available postoperative beds and resources which also impacts the behaviour. It is therefore important to make sure that the model can reproduce the empirical behaviour so that one can relay on the results from the different policies despite the shortcomings in the models framing and the different time variables.

In this behaviour reproduction test I have used the base model to recreate the operation program as it was performed in 2004 at the modelled operation theatres. Empirical data from 2004 where used in the base model consisting of all of the surgeries performed at the modelled theatres together with their different performance times for the different activities. Meaning that if a patient with a dislocated hip had, in 2004, a surgery time of one hour the modelled resources performing the specific surgery in the model was given a one hour performance time of the surgery. The operation program at all of the operation theatres where assembled in a similar matter making a daily operation program equal as performed in 2004. The operation types that had been performed in 2004 where connected to the same operation theatre together with the date that the operation where carried out. Meaning that all of the operation that where performed at operation theatre number 6 at 01.01.2004 where, in the model, added to the operation program at the same date 01.01.2004. It has not been possible to asses the amount of overtime performed in 2004 so the model does not restrain the amount of overtime. The time horizon where set for one year.

The simulation results produced by the model where compared to empirical data. The figure below shows a brown line which is the total number of surgeries performed at each sections surgery theatre in 2004. The yellow line gives the number of performed surgeries performed in the model through out the year.

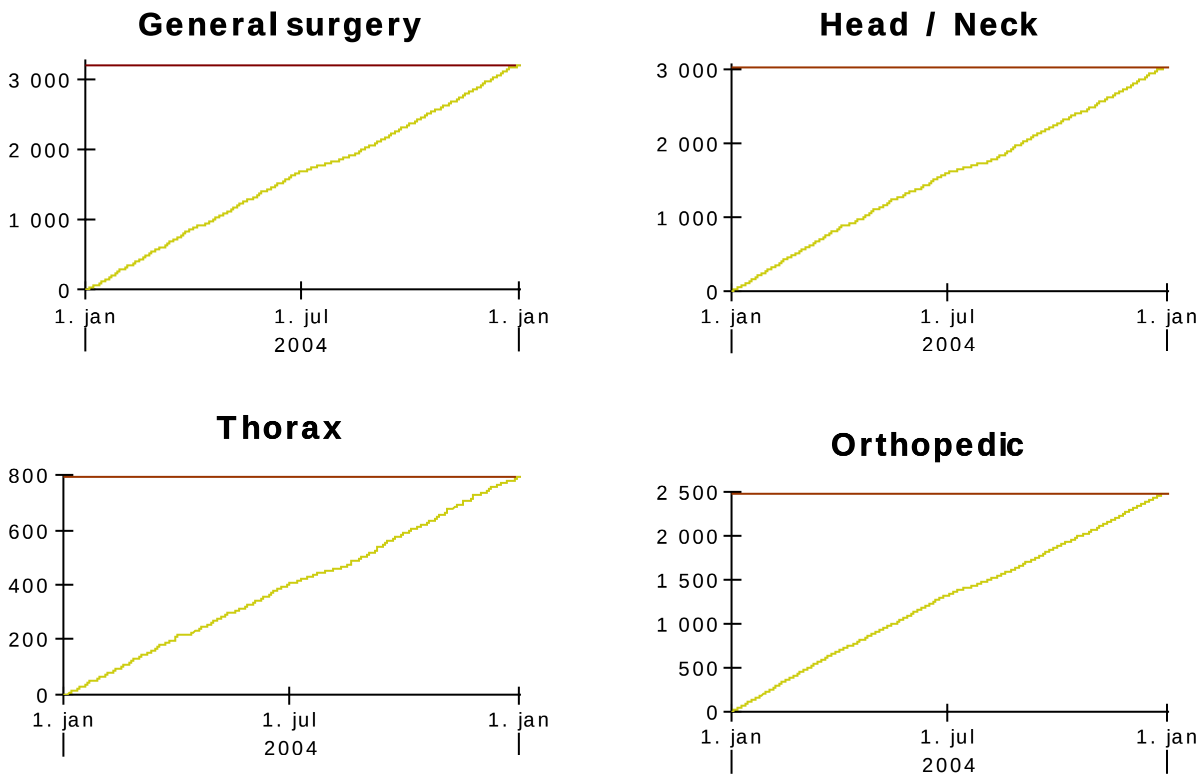
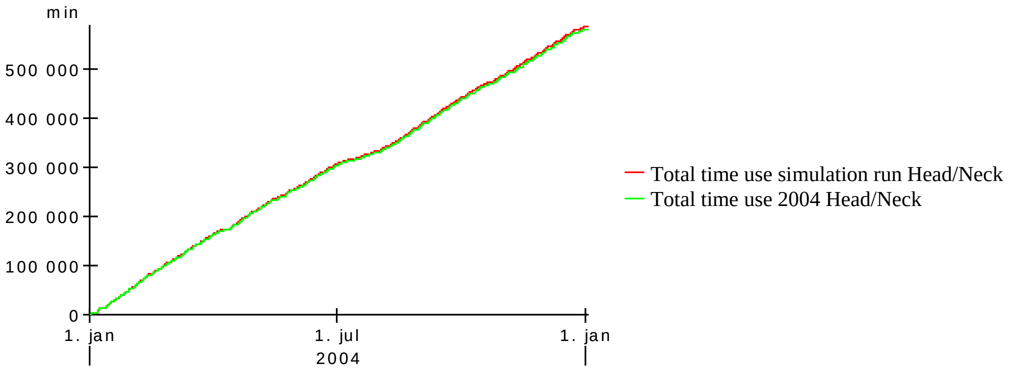


Figure 45: Number of performed operations in the simulation run up against the real number in 2004

The results from the behaviour test shows that the model can recreate empirical data by fore instance performing the same amount of operations as performed in 2004 (the yellow line reaches the brown line at the end of the year/simulation run). The total activity time produced at each section, in the model, also resembles the total empirical activity time (See figure 46 and 47). This illustrate that there are no elements in the model that hinders it to recreate real behaviour and that the different limitations in the model is genuine. If the model had not able to perform all of the operations or had used more time it would have been hints of shortcomings or errors in the model. This could have been delays crated by the model that made the waiting time bigger, limitations restricting the patient flow to SOP modelled wrong giving an incorrect presentation of the flow or wrong modelled prioritizes reducing or stopping the patient flow making the model unable to recreate empirical data.

The graphs below shows the total activity times resulting from the simulation run together with empirical data from 2004. The discrepancy between the empirical and simulated times is at each section smaller then 3% which is seen as an acceptable difference.



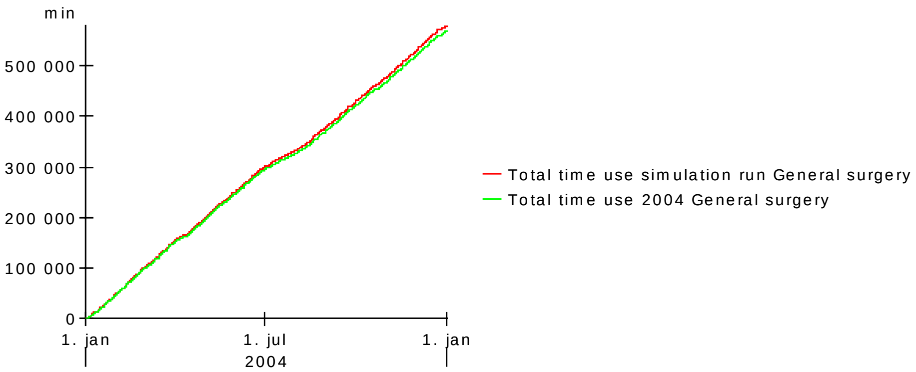
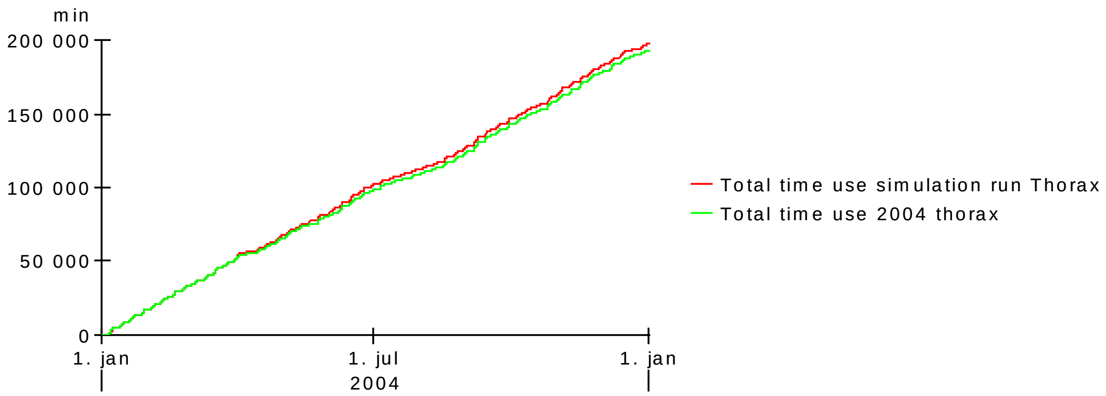


Figure 46: Results from the simulation run comparing the simulation results with actual data at sections modelled without personnel attachment.



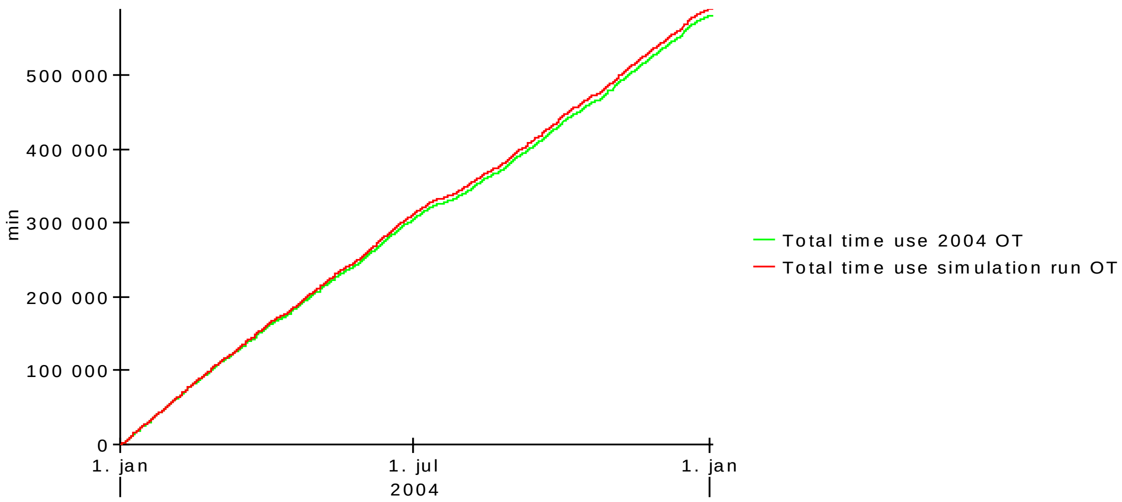


Figure 47: Results from the simulation run comparing the simulation results with actual data at sections modelled with personnel models.

The model is able to replicate the behaviour both in sections modelled with and without personnel model attachment and the chosen boundary does not exclude important variables that can affect the patient flow or the resource use. As illustrated in the different results the model reproduces a behaviour with good resembles to reality. The different personnel models work together giving the correct patient flow and at the same time do not produce behaviour that does not resemble reality.

4.3.2 Extreme condition tests - Assuring compliment of physical laws and endurance of extreme conditions

Part of the model validation consists of assuring that no physical laws are broken and that the model can handle extreme conditions. Models should be robust in extreme condition meaning they should behave in a realistic fashion no matter how extreme the inputs or policies imposed on it is. Such test quickly uncovers flaws and is a great advantage in a large model (Sterman 2000). Several extreme tests have been performed on the base model in addition to tests uncovering violation of physical laws.

Extreme test 1 – Absence of patients

The models complexity and extent makes it necessary to make sure that the most important connections between the models are correctly modelled. The two first extreme test aims at testing for weaknesses between the personnel model parts and the patient flow.

In the first extreme test there will be no patients to treat. The personnel arrive at SOP everyday to treat patients. And there is an evident need for patients to be at SOP to able the personnel performing their tasks. The first extreme test is to assure that activities are only performed if there are patients to treat. In the test, all inflows of patients in the model are set to zero. The model structure and model inputs of personnel will not be changed and will be equal to the reality. The model is rune for one day. If the model complies with real life reason no activities should be performed and all personnel cost ought to be connected to “free time” for the personnel - time consume not linked to patient treatment.

The illustrated results are collected from one section (OT) but the Thorax section gives a similar behaviour. The Head/Neck and General Surgery section does not have personnel models connected to the patient flow. With an input of zero patients the two sections did not produce any behaviour (see figure 48 and 49)

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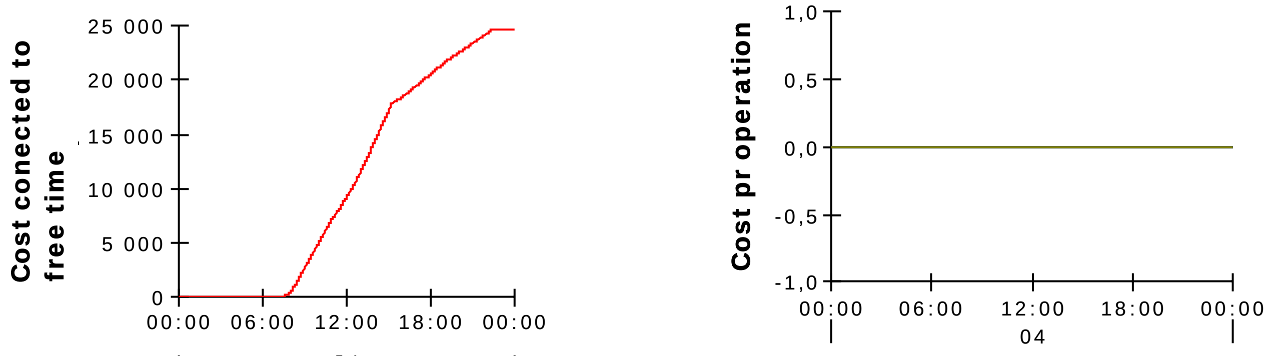

Figure 48: Costs connected to free time for personnel and operations.

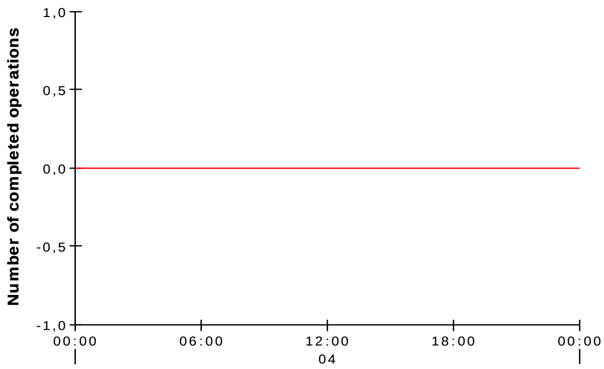

Figure 49: Number of performed operations

The behavior produced by the model shows that no operations have been performed and all costs are considered to be non-efficient cost meaning they can't be connected to any operation. The model can manage a zero input of patients and does not produce any activities connected to patients unless there are patients to treat.

<u>Extreme test 2 – Absence of personnel</u>

The first test showed that the personnel do not perform patient flow activities unless there are patients to treat. The personnel models link to the patient flow is an important connection and needed therefore to be further tested. If the connections are incorrect or the model can not give a reasonable behaviour under extreme condition the model needs to be corrected.

Equally as the personnel activity performance is dependant on patients the patient flow is dependant on the presence of personnel. Patients can't be treated unless the needed personnel are present. The second extreme test sees if the model complies with these terms. In the test the operation nurse and the anaesthesia nurse, working at the surgery theatre number six at the OT section, will not be present – meaning that the inflow to these personnel models will be set to zero. There have not been made any other changes to the model. It is sufficient to test one operation team because the patient flow is equally dependent on the personnel at all of the operation theatres modelled with personnel. The behaviour produced by the model is illustrated in figure 50.

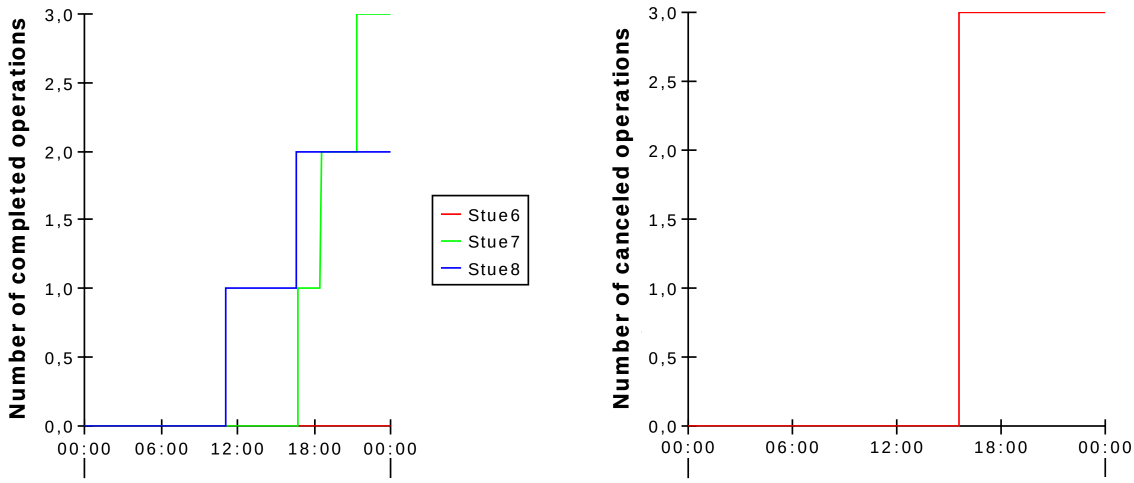

Figure 50: Number of completed and cancelled operations.

As showed in figure 50 the operation theatre lacking personnel (stue 6) does not perform any operations because parts of the staff are missing. The operations planed to be performed at the operation theatre are therefore cancelled. The test illustrates a real life situation which occurs when people are sick or are for other reasons absent from work. It is not always possible to replace missing personnel and the models behaviour is equal to reality – the surgeries are cancelled. The two extreme tests shows that the connection between the patient flow and the different personnel models are robust and can handle extreme conditions.

<u>Extreme test 3 - Big input of acute patients</u>

The former extreme tests have showed that the model can handle absence of people and personnel. There is also a need to see if the model can handle a large input of patients. Since elective patients are planned and the inflow of these patients is controlled by the hospital, the test will consider a large input of emergency care patients. The extreme test will see if the model can not only handle are large input, but if it also can prioritize equally to the real sections when the input of emergency patients are large. Emergency care patients are to be prioritized before elective ones, but the prioritizing is handled differently at the sections. At the Orthopaedic section one operation theatre is isolated to only operate immediate care patients. The capacity of this theatre is not always enough and the queue of patients can be long. If the waiting time for emergency patients exceeds the set emergency degree the patients are operated at the first available operation theatre and elective operations are postponed. The remaining sections at SOP prioritize differently. They do not have theatres put aside to only operate immediate care patients but directs the acute patients to the first available operation theatre.

The test is performed at two sections (OT and General surgery). The sections are chosen because they prioritize differently. The modelled priority at General surgery is equal to the Head/Neck and Thorax section making it unnecessary to also test these. At the beginning of the simulation there will be an input of 40 emergency patients at each of the sections (OT and General surgery). The run time is two days and the set emergency degree of the patients is over 8 hours which is the most common degrees. No other changes have been made to the base model. The surgery program is therefore planed equally as in the base model and the different patients are given operation types as explained in chapter 3. The results from the extreme test show that the operation theatre with a planed operation program (number 6 and 8) at the OT section performs the program the first day (figure 51 and 52). At the second day emergency patients are operated at these theatres and the planed program is cancelled (figure 52).

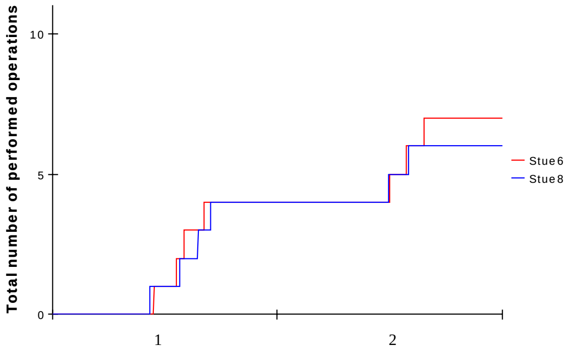

Figure 51: Performed operations at the operation theatre number 6 and 8.

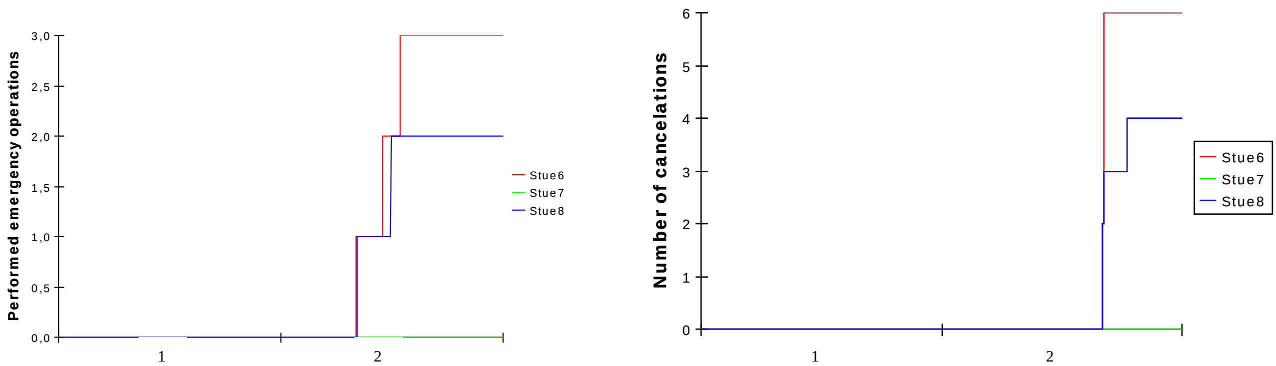

Figure 52: Validation results from the OT section showing performed operations and cancellations.

The emergency patients are not operated at these theatres the first day because the patients have not waited longer then the set emergency degree. The emergency degree is the term deciding whether an emergency operation is to be performed at an elective theatre. At theatre number 6 there have been planed more surgeries then at number 8 leading to a bigger number of cancellations at the theatre. The operation theatre operating emergency patients have operated emergency patients both days.

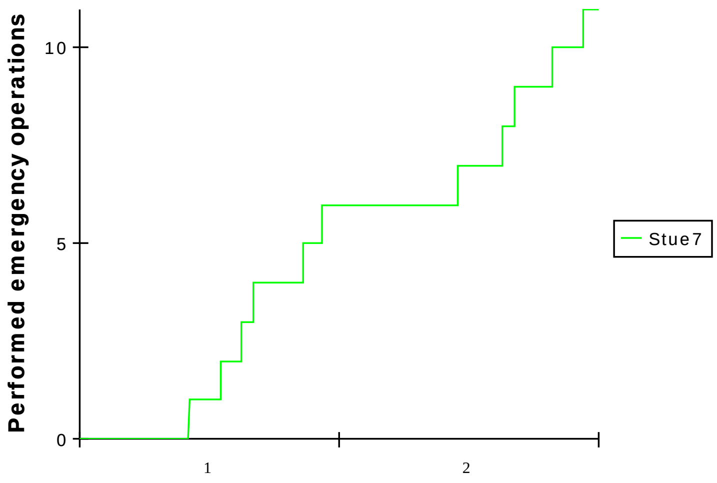

Figure 53: Emergency operations performed at the emergency operation theatre at the OT section.

Test results from the General surgery section shows that the emergency patients are operated at the first available operation theatre and prioritized before elective operations (figure 54). This occurs even though the patient has not waited longer then the set emergency degree.

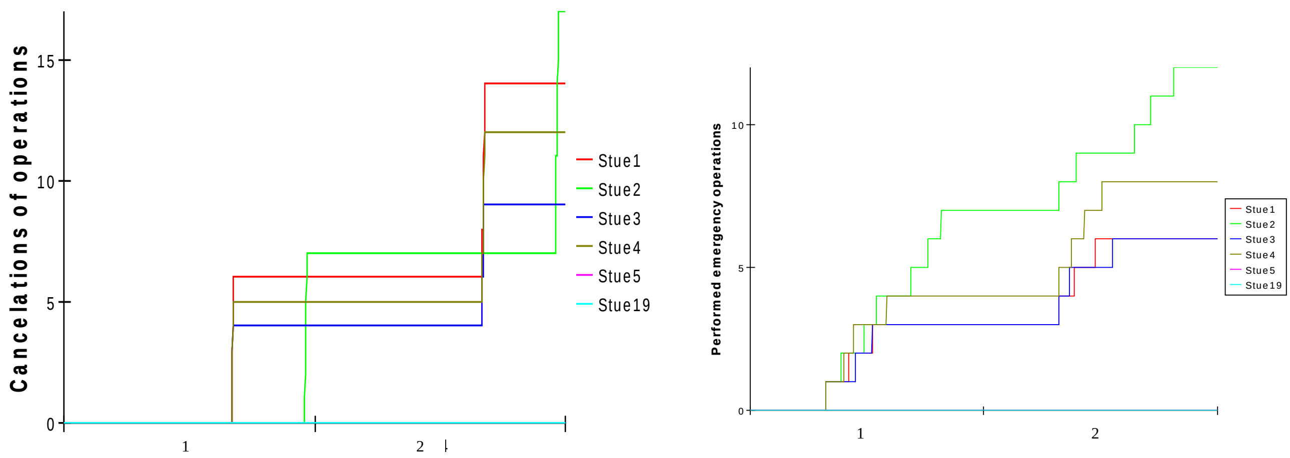

Figure 54: Results from the validation test from the General Surgery section.

The planed surgeries are cancelled due to the prioritizing of emergency patients. One surgery theatre (stue 2 – green line) performs more surgeries then the other theatres because there are tow shifts at this theatre (day and evening shift).

The results illustrate that the model can handle extreme inputs and still give a correct behaviour. The model also gives an expected and correct respond when it comes to prioritizing emergency patients even though the input is large.

4.4 Sensitivity analysis

The validation tests have revealed weaknesses in the model and pointed out its shortcomings. In the sensitivity analysis two elements pointed out in the structure assessment test will be further analysed. The tests will show if changing parameters values or an activity will have big effect on the models behaviour. The tests performed in this chapter will have a short time horizon, from one day to a week, to assure that small changes will be discovered. To limit interactions that might influence the results the tests will be run with only one section (OT). The other sections will not produce any behaviour. The same operation program will be performed within the different tests and activity times will be static meaning they will not change during the different runs.

4.4.1 Division of the preparation time between the different anaesthesia nurses

As mentioned in the structure assessment test the preparation of patients is divided into two activities having two anaesthesia nurses performing one part each. The empirical data gives the total preparation time and it has not been possible to divide the time into two separate performance times for anaesthesia nurses. The division of the total performance time between the two activities have therefore been based on interpretation of information and assumptions. The anaesthesia nurse at the operation theatre is to perform 30% of the total preparation time and the responsible anaesthesia nurse 70%. The division is based on collected information and assumptions. This leads to a need to asses the models sensitivity and the test will reveal if changes in the percentage division has impact on the patient flow. The test will be performed using one section (OT). For each run the percentage division of the preparation time, between the two nurses, will be changed as illustrated in the table below. The testes divisions are chosen due to the fact that the nurse at the operation theatre does not perform more of the total preparation then the responsible nurse. There will only be performed one type of operations so all of the patients in the flow are given the same operation type. The base model has been used in the test runs and the time horizon was set to one week.

Percentage of total time	Responsible nurse	Nurse at operation theatre
Test 1	50 %	50 %
Test 2	60 %	40 %
Test 3	70 %	30 %
Test 4	80 %	20 %
Test 5	90 %	10 %

Table 3: Percentage division of preparation time

The different tests did not affect the number of operations performed because an equal number of operations where performed at all of the tests. The division of the preparation time did however have an impact on the different delay times (See table 4). The different times in table 4 are the total time of all the performed surgeries. The added delay time during preparation is the discrepancy between the activity performance time and the total time use produced by performing the preparation activity. The times are measured in minutes.

Run	Added delay time during preparation	Waiting time locking patient inn caused by missing nurses	Waiting time locking patient out caused by missing nurses
Run 1	143	31	24
Run 2	114	10	41
Run 3	87	10	43
Run 4	110	35	52
Run 5	116	20	68

Table 4: Results from the different runs

The first and the last test are extreme points and would not likely be the actual percentage division in the real world. It is therefore interesting to see that they give the biggest added delay times during preparation and among the biggest waiting times for locking the patient in and out (Run 5). The waiting time when locking patient out increases when the preparation done by the responsible nurse increases. This occurs because it is the same nurse that locks patients out of SOP that performs the preparation at the preparation room. The more time this nurse spends on the preparation the more time is added to the locking out activity. The different delay times might seem high but are results from three surgery theatres operating patients a hole week.

The model shows some sensitivity to change in the division of the preparation time but the impact not big enough to have impact on the total patient flow. The changes in the division of the preparation time performed in this test shows that it does not have big impact on the patient flow. The percentage division used in the model is a 70 – 30 % division of the total preparation performance time. This division does not contradict information given to me through interviews or from the ABC-analysis and gives a model behaviour more similar to reality.

4.4.2 The lunch activity

The lunch activity is an important daily event, but the modelled activity's impact on the patient flow might be limited due to some flexibility restrains in the model (for further explanation see chapter 4.1.1). It is therefore important to test the models sensitivity to this issue to see if the present of the activity have the expected impact on the patient flow.

The sensitivity test is performed through two simulation runs. The base model is used in the first run which includes the lunch activity. In the second run there have been done some alterations to the base model and the lunching activity has been removed. The test is performed at the OT section, but the Thorax section (also modelled with personnel models) is built in the same manner as the OT section and would therefore give similar results. The model is run for two days and the patients being operated in the model are given the same operation type to prevent differences in the runs. There are not performed any operations at the other sections to avoid interruption from other patient flows.

The results from the two runs shows that a better patient flow is achieved if the lunch activity is not included in the model – more surgeries are performed (illustrated in table 5). There is also a big discrepancy between the free time for the nurses (responsible and middle watch). They assist when operation nurses are at lunch and by not including this activity their function in the simulation model diminishes and the model would deviate from reality.

	Performed operations	Cancellations	Séance time	Free time for operation nurses (responsible and Middle watch)
With Lunch	25	3	02:40:06	07:56:00
No Lunch	26	2	02:41:08	19:31:00

Table 5: Results from the sensitivity test.

The results illustrate a better patient flow if the lunch activity is not included - making resources more available in the model. By excluding the lunch activity some resources would lose various functions in the model and the model would deviate from reality. The lunch activity is important in the model despite the flexibility restrains. There was suppose to be performed 38 lunches in the simulation run but only 34 where actually performed. The model produces behaviour closer to the reality with the lunch activity.

4.5 Summary

Barlas states that "An analyst who has spent a lot of effort on the quality of the model in the model conceptualization and formulation phases, will naturally spend relatively less effort in the "formal" validation stage" (Barlas, 1996:184). While building the model presented in this thesis I have spent a lot of effort on these elements and have in the formal validation of the model focused on uncovering an explaining the weak points of the model and validated the models structure and produced behaviour. The behaviour test shows that the models structure and behaviour can replicate empirical data and the extreme tests showed that the model behaviour do not contradict reason in extreme conditions. It has also been showed and explained that the lacks in the model does not prevent the model to be adequate with respect to the models purpose.

5 Policy design

Through creating new strategies, structures or decision rules, policy design tries to improve the system. Policy designs often result in changes in parameter values and in the stock and flow structure - aiming at changing the most dominant feedback loops. The stock and flow structure in this thesis model is based on the working assignments (activities), patient flow steps and physical structure within the Central operation division. The policies will focus on changing strategies and policies used today by altering parameter and premises within the system. The goal is to improve the patient flow and the utilization of resources at SOP through resolving problems within the system.

The main hypothesis has been operationalized through several hypotheses based problems related to the problem statement. A policy aims at testing the hypothesis resulting in a strengthening or discarding. Some of the policies will be run after the idea of the Steepest Descent method meaning that if for example the results of the test shows that added resources is needed, the policy will be run with more resources finding how many resources that are needed to achieve a good result. The different results will first be presented and explained before they are assessed up against each other. Policies directed towards different issues will be tested together to evaluate improvements in results or if policies becomes redundant. At the end there will be a summary of the result with a conclusion and elements that needs further research.

5.1 Policy design and results

The policy models originate on the base run model with some adjustments which will be described at each policy. Some of the policies will be tested at all of the sections while others will only be tested at OT. The OT section is the main focus of the policy design and most of the changes will be directed toward this section. Results from all of the sections will be presented if the policy introduced in the OT section has had implications for the other sections. The results from the policy runs are compared to those from the base run and the differences are presented in the form of percentages. To reduce uncertainties there will be an equal number of emergency patients given as an input to the model in the policy runs and the base run. This will also give a better comparable foundation between the different results. If the number of emergency patients was allowed to fluctuate between runs it would affect the simulation run results in making them hard to compare. The time horizon is set to one year.

Results from the policies will be compared by looking at three main criteria; patient flow (and associated average costs), resource utilisation, and delays. Patient flow is measured by considering:

- number of operations performed
- number of cancellations
- séance time
- number of emergency patients undergoing surgery at theatres set aside for elective treatment (to demonstrate interferences between planned and unplanned operations)
- waiting time for emergency patients
- the time difference between the actual starting time for a surgery and the planed starting time for the surgery (indicates interference in the flow and delays)
- the changing time between the different surgeries.

Resource utilisation and delays are implied through looking at:

- waiting time for various personnel
- amount of overtime
- unused capacity meaning time not spent on treating patients and the connected costs (cost connected to free time)
- increased activity times and resource usage.

I will also look at cost pr operation meaning total costs, connected to the performed surgeries and cost that are produced but that can not be connected to surgeries due to cancellations or delays, divided on all of the performed operations. In what follows, I will present and discuss important behaviour modifications resulting from the introduction of various policies as well as unexpected results. Small changes in presented results might not always be discussed because they can be related to uncertainties in the model and not related to changes produced by the policy. The different policy results are presented in tables and showed as percentage change compared to the base run.

5.1.1 Base run

The base model of SOP has been run without any attempt at improving the patient flow. Surgery types are based on real data from 2004 and activity performance times are based on empirical data as explained in chapter 3.4.1. As previously explained, the emergency care patients are distributed statistically across time corresponding to the empirical distributions. Results from the run have been compared with the policy results to see if a policy has lead to improvements in the system. Moreover, in the model, personnel arrive at what corresponds to the starting time for various shifts. The base model does not initiate a surgery if the planned séance time results in overtime for the personnel meaning if the next surgery planed time exceeds the remaining time of the shift. But, in the model, as in real life, overtime will arise if a surgery already in progress takes more time than planned – the actual séance time exceeds the planed séance time. The various parameter values, such as vacation time, number of patients within an operation type, time delays caused by elements outside the boundary, arrival time and ending time for the personnel, unit costs are listed in the equation in the model (See Appendix).

5.1.2 Policy 1 – decreasing delays

The patient flow through SOP is influenced by both exogenous and endogenous factors and they can both cause delays in the system. One reason for delays caused by exogenous factors is the late arrival of surgeons. In fact the hospital considers the late arrival of surgeons to be a bottleneck inflicted on to the system. A hospital report states that, on an average, the surgeon arrives 15 minutes late at SOP (Haukeland sykehus, 1998 b). The operation start is dependent on a presence of surgeons and late arrivals create delays in the system. An overdue operation start has ripple effects leading to delayed arrival of the next patient and an even more delayed operation start that increases the backlog of surgeries to be conducted (reinforcing feedback-loop). The cumulative delays throughout a day at a surgical theatre may lead to cancellation of surgeries. Thus one may formulate the hypothesis; *Delays caused by exogenous factors acting upon the system reduces the patient flow.*

The first policy is to reduce the delay time of the surgeon. This is considered to be the major single delay factor. In this test case, the time delay for the arrival of a surgeon has been reduced to zero to demonstrate its effects. The model is otherwise equivalent to the base model. This policy is introduced in all of the sections modelled to investigate whether the hypothesis applies to them all. A larger throughput of patients is an expected result from this policy. Since no additional resources have been added, we also anticipate a reduction of costs as a result of fewer delays and, consequently, a better resource utilisation. If there is any hold to the hypotheses the séance time should also be less then in the base run because the late arrival of a surgeon leads to a longer séance time for the patient.

Results

In one report, the hospital states the expectation that production (i.e. throughput) will increase by 3 % if the surgeon arrives on time (Haukeland sykehus, 1998 b). The overall result from the four sections gives an increase of about 3 %, another consequence of the improved throughput is a reduction in cancellations (table 6).

Changes in patient flow	Performed operations	Cancel - lations	Cost pr operation	Average séance time	Emergency patients operated at elective theatre	Average waiting time for emergency patients	Total time difference between planned and actual surgery start	Average changing time
OT	3 %	-8 %	-4 %	-6 %	-12 %	-2 %	3 %	8 %
Thorax	3 %	-24 %	-1 %	-1 %	*	-10 %	6 %	9 %
Head/Neck	6 %	-13 %	*	-6 %	*	-10 %	6 %	6 %
General surgery	3 %	-10 %	*	-6 %	*	-6 %	Missing data	3 %

Table 6: Results from policy one regarding changes in the patient flow (Not applicable).*

The reduced exogenous delay results in less interference between emergency and elective treatments given by a reduction in number of emergency patients operated at elective theatres (OT section). Cost is decreased and the average séance time has also dropped. The trend among other sections is similar. Differences in percentage increases and reductions in the results between the sections are caused by distinctions between the section number of emergency and elective patients, available resources, shifts arrangements and so on. But despite these differences the outcome shows that having a surgeon on time gives a better patient flow. The reduced delay affecting the patient flow is not enough to reduce the changing time or the time difference between planned and actual surgery start. The performance raise leads rather to an increase of these parameters (table 6).

Increased production, without adding resources, indicates better resource utilization. As portrayed in table 7, the reduction of delays gives more idle time for the personnel, but the time freed up is not fully utilised – indicated by the 10 % increase of non use of the operation theatre (OT) and added free time resulting in a raise in cost associated with the free time.

Unused capacity	**Cost associated with to idle time**	**Idle time for personnel**	**Free surgical theatre time**
OT	6 %	6 %	10 %

Table 7: Cost and time use which can not be connected to a specific operation type.

The result is, however, that the overtime for the personnel decreases (table 8) due to a reduction in delays and the production is raised, *in itself* a significant financial improvement, and an improvement in the general work environment and in service quality (less waiting time for patients, table 6). The added production has resulted in more pressure on the locks and, consequently, patients have to wait longer for a vacant lock (table 8). The later arrival at the preparation reduces the waiting time for the patient before the operation theatre is cleaned (preparation of operation theatre).

Added times	Waiting time outside lock	Waiting time locking out	Preparation of operation theatre	Extend finalization	Overtime for personnel
OT	3,6%	9%	-7 %	-16 %	-7 %
Thorax	12%	15%	-8%	14%	-11%

Table 8: Results from the first policy giving parameters concerning waiting time for vacant lock, extended finalization and overtime for personnel.

Due to delays in the system the finalization can be extended leading to waiting time for the next patient in line to use the surgery theatre. But, by lowering the waiting time for the surgeon, the extended finalization is also reduced. Waiting for surgeons is a reason for why operations take longer time than planned and delaying finalization of the associated surgical procedures as well as preparations for the next patient in line for surgery. By reducing the arrival delays for surgeons, the time diminishes as showed in table 8. The added waiting time outside the locks detains the start of the preparation activity which, together with reduction of extended finalization, reduces the delay caused by waiting for a cleaned operation theatre. The prolonged finalization at the Thorax section results from an increase of 9 % waiting time for anaesthetist (table 9). The small amount of patients passing through this section leads to larger variety in the results than what we find in the other sections. The additional effects resulting from this policy are in general a significant increase in pressure on the personnel due to a larger inflow of patients. This implies that delayed times (table 9) due to late arrival of personnel at an activity increases and the available personnel is better utilized. The added waiting time is caused by the fact that personnel, when treating patients, are often required to be at several activities at the same time. The amount of added free time is evidently not sufficient to allow for additional patients to undergo surgery. In part, this is a result of the fact that all the resources required to conduct a surgical procedure need to be available simultaneously for additional patients to undergo surgery. In the presence of only a couple of these resources, the remaining ones have to wait, - a waist that results in reduced overall efficiency.

Waiting for personnel	Hospital orderly (locking inn)	Hospital orderly (preparations at SOP)	Anaesthetist (preparations at SOP)	Surgeon	Anaesthetist (finalization)
OT	-13 %	9 %	13 %	-92 %	3 %
Thorax	32 %	8 %	-38 %	-91 %	9 %

Table 9: Activities where different personnel does not arriving when needed leading to delays.

The waiting time for the surgeon has been completely eliminated, except for a single time step of one minute delay remaining.

In summary we may claim that the policy yields a larger production and improved resource utilization due to less overtime and at the same time an increased production. It also shows that exogenous impact can become a bottleneck in the system as explained in the introduction to this policy. By reducing the waiting time for the surgeon the pressure on other bottlenecks increases, like waiting for an available lock and resources. The hypothesis is strengthened by way of these results. Focusing on reducing delay factors can make the patient flow more smoothly.

5.1.3 Policy 2 – improve operation program planning

In any organisation planning is an important activity. Scheduling the surgery program at SOP is a significant element in hospital planning as the SOP resources are shared across patients from a variety of wards, and this planning process thus affects the overall performance of the hospital. The hospital underlines this fact in a report about patient flow. One conclusion is that inadequate planning is a reason for cancelled operations. The report also states that each cancellation cost the hospital 20 000 NOK (Haukeland sykehus, 1998 b) which is a loss, difficult to compensate for. The surgery programs at the various sections are primarily based on planed performance times of activities associated with the various classes of surgeries. These planned times are determined by the “surgery card” for the specific surgery and are not based on data reflecting the experience that SOP has with the time it takes to complete various surgeries, - leaving us with a static perspective. This leads up to the next hypothesis:

Improving the planning of the surgery program will increase the predictability of the program and, thereby, the patient flow.

It is important to reduce the share of cancellations to reduce the income loss for the hospital and for the inconvenience this causes for the patient. The patient might have been admitted the day before, fasted and started a treatment in preparation for the surgery. Cancellation of the procedure may result in discharge for the patient only to be admitted at another time or perhaps in a prolonged hospital stay for the procedure to be repeated, and holding a bed that another patient is in need of. There is also the psychic strain and added stress for the patient experiencing such postponements.

The policy discussed here has been designed to uncover potential improvements in the patient flow resulting from the planning of the program being based on surgical time estimates that reflect experience. The time estimates are calculated using actual performance time spent (using as a point of departure the card estimates otherwise applied in the planning process) and provide the average performance times of an activity associated with a specific kind of surgery. These estimates will be applied when planning the surgical program and also to determine when to call the next patient to SOP. This new way of establishing the planning time will apply to all the four surgical sections. If the hypothesis holds, then the number of cancellations should drop and the need for overtime will diminish. I would also expect that the surgeries would start closer to the time they were planned to start.

<u>Results</u>

This policy results in an overall, extensive reduction in the number of cancelled surgeries due to a better planned surgery program (table l0). Using actual performance activity times when planning the program means that the planed activity times are more equal to the actual time a patient at SOP is at the activity. This gives a planed surgery program more equal to the actual performed program. This is one factor that leads to lesser cancellations because the surgery program is more feasible (table 10). The policy reduces the chance for a planned surgical program to contain more operations that what is possible to perform during a shift (reduces the number of cancellations). And also, that the surgery team finishes the program long before the shift is over giving a better resource utilisation (illustrated in table 11 which shows a reduction of free time for the personnel).

There is a small reduction in surgeries completed at the section for General surgeries. The reduction is caused by the changes in the planning of the surgery program leading to fewer planned operations, at this section. At the other sections, the production is not affected or slightly increased, suggesting that the change in policy for planning surgery programs can lead to more performed operations due to better planning (table 10). Improved planning also improves the flow giving a higher accuracy as to when the next patient should be called to SOP, reducing the time difference between the planned and actual surgery start and the changing time between the different surgeries. This accuracy also gives a faster flow and reduces the interference between the emergency end elective flows (emergency patients being operated at elective theatres). This higher accuracy reflects the reliability in the calling of the patients to SOP that is actually experienced by the personnel at SOP, resulting from flexibility in the calling procedure based on judgements. Note, however, that if a patient is called to SOP before the time planned, the ward may not have had time to prepare the patient in time. This underscores the importance of a reliable and feasible program.

Changes in patient flow	Performed operations	Cancellations	Cost pr operation	Average séance time	Emergency patients operated at elective theatre	Average waiting time for emergency patients	Total time difference between planned and actual surgery start	Average changing time
OT	3 %	-44 %	-11 %	-3 %	-23 %	-11 %	-2 %	-15 %
Thorax	0 %	-6 %	-2 %	7 %	*	-5 %	8 %	5 %
Head/Neck	5 %	-32 %		1 %	*	-9 %	-2 %	-16 %
General surgery	-1 %	-47 %		2 %	*	2 %	-19 %	-14 %

Table 10: Results from the second policy giving changes in the patient flow (Not applicable).*

Cost pr operation is also reduced at the OT section due to an increase in production and reduced time a patient spends at SOP (average séance time in table 10). The various sections respond differently to this policy. The surgical times at the Thorax section are close to those recorded on the surgical cards and the changes from a card-based planning process are therefore small. The other sections experience a significant reduction in cancellations, smaller changing time and less discrepancy between the planned and actual starting times. The reductions in these parameters are not enough to decrease the average waiting time for emergency patients at General surgery. There is actually an increase in the average waiting time for emergency patients that can be due to the increased number of surgeries performed at the OT and Head/Neck section. These sections, OT, General surgery and Head/Neck, shares the beds at the postoperative division. The increase in surgeries at the two sections can reduce the number of available beds. As a result of this the emergency patients have to waiting longer. It a patient needs further treatment at the postoperative division it can not be operated before there is a vacant bed at the division (see policy 8).

Unused capacity	Cost associated with to idle time	Idle time for personnel	Free surgical theatre time
OT	-2 %	-2 %	-1 %
Thorax	0 %	2 %	-3 %

Table 11: Cost and time use which can not be connected to a specific operation type.

As is true in the case of the former policy, there is a better utilization of the available resources (table 11). There is a huge reduction of overtime (table 12) and even a small reduction of free time for the personnel at the OT section. Less overtime is another reason for the reduced cost pr surgery.

Added times	Waiting time outside lock	Waiting time locking out	Preparation of operation theatre	Extend finalization	Overtime for personnel
OT	1 %	8 %	46 %	61 %	-19 %
Thorax	5 %	12 %	8 %	18 %	-15 %
Head/Neck	-1 %	11 %	*	*	*
General surgery	1 %	-1 %	*	*	*

Table 12: The table shows delay times before activities, extended finalization due to delays and overtime for personnel resulting from the policy (Not applicable).*

Added times due to preparation of operation theatres and finalization have doubled at the OT section. Patients are more on time at SOP resulting in delays that where previously not evident to emerge. These delays where before covered because the planed times where not close to the actual performance times. One of these delays is the time it takes to wait for a clean surgery theatre (preparation of operation theatre in table 12). The patient at the preparation room is ready to enter the operation theatre closer to when the patient at the surgery theatre is finished. This is a reason for the reduction in the changing time (table 10). But the time it takes to clean an operation theater is not included in the planning of the surgery program and does therefore become more evident (the exclusion of the cleaning time is equal to how the program is planed at the hospital). The delay caused due to waiting for a clean operation theatre might be reduces if the cleaning time was included in the planed surgery program. The increase in the extended finalization is also more evident because both the patient at the preparation room and the patient at the finalization are in need of the anaesthetist which can only perform one activity at once. Another reason for the prolonged finalization is that the surgeon is in this policy late for the performance of the surgery. The delayed start of the surgery leads to a later start up of the finalization. The next patient in line for surgery will therefore experience an extended finalization. This also delays even further the cleaning of the operation theatre.

A better planning of the surgery program reduces the chances for planning more surgeries then what is realistically too performed during a shift which is more likely when not using experienced data. Results are better predictability in the flow and a reduction of cancelled operations that would not have taken place anyway. The policy also gives an increased resource utilisation.

5.1.4 Policy 3 – allowing for overtime

There are many uncertainties associated with surgical procedures which in calls for overtime for the personnel. In general, SOP tries to minimize the use of overtime. One attempt to reduce overtime is not to initiate surgeries that might last beyond the length of a shift. The result is an early de-escalation of surgery starts at SOP.

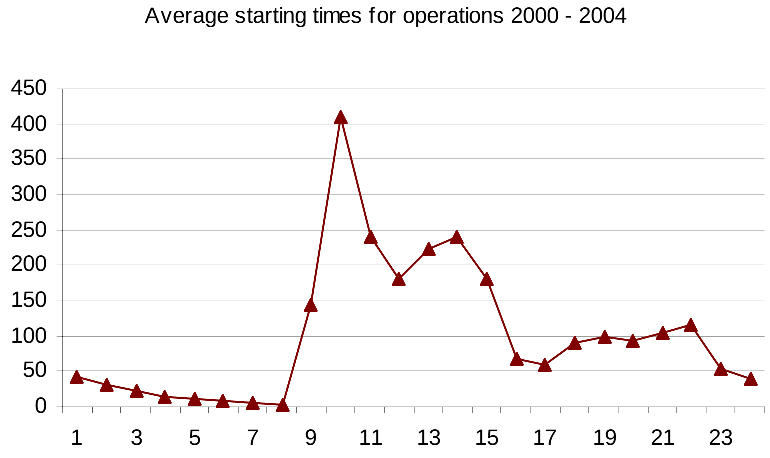

Figure 55: The figure shows average number of surgeries that is being started within the different time spans within a year (OT section).

Figure 55 illustrates an early de-escalation around twelve before a small increase and then again a drop around four o'clock. Surgeries started after three o'clock are mostly emergency surgeries. The policy of preventing overtime may lead to a non-optimal utilization of the personnel because surgeries are not started creating free time for the personnel towards the end of the day. One could reasonably expect that more surgeries could have been completed provided there was some flexibility at the end of the day allowing for dayshift overtime. So the hypothesis would be: *Exercising a certain flexibility regarding when dayshifts should end will prevent patient flow obstructions from early daytime de-escalation.*

The hypothesis has been tested by allowing for overtime for the personnel involved. Two simulation runs have been conducted with a certain increase in overtime allowance. The overtime will only be allowed at the OT section, the other sections will operate under the conditions specified in the base run. Both of these new runs allow for overtime at the dayshifts connected to the theatres performing elective surgeries (at the emergency theatre there is an evening shift taking over from the dayshift and overtime is not necessary). If there are more elective operations to be completed the personnel works overtime, they will otherwise end their shift if all of the planed operations are performed before overtime is needed. The first run will allow for only one hour of planned overtime and the second run allows for a maximum of two hours. This means that if, for instance, the last operation is expected to require three hours overtime, and the limit is two, then the operation will not be started. In the outcome of the policy run it is expected that this policy will cause a later de-escalation, resulting in an increase in the number of surgeries completed.

Results

Allowing for overtime has, so far, been the policy leading to the best increase in production (table 13). The surgeries planned completed late in the day are actually being completed, effectively reducing the number of cancellations because more of them were actually being performed.

Changes in patient flow	Performed operations	Cancella tions	Cost pr operation	Average séance time	Emergency patients operated at elective theatre	Average waiting time for emergency patients	Total time difference between planned and actual surgery start	Average changing time
1 hr overtime	5 %	-13 %	-3 %	1 %	-1 %	2 %	32 %	5 %
2 hr overtime	9 %	-37 %	-3 %	-2 %	5 %	4 %	73 %	9 %

Table 13: Results from policy three showing percentage changes in the patient flow (Not applicable).*

The cut in cost pr surgery is predominantly caused by misrepresentation of the unit costs. When accepting overtime there needs to be an upwards adjustment in the unit costs that we have not included in the model. If we expect a 50 % increase in unit cost for overtime the cost pr surgery will result in a 2 % reduction of total costs around when allowing for one hour overtime and a 2,6 % reduction when allowing for two hours overtime.

Both tests demonstrate that the discrepancy between the planned surgery start-up times and the actual time for start-ups increases with the introduction of overtime (table 13). The surgeries scheduled to take place late in the day are actually being completed and not cancelled. The use of overtime does not, however, cause the surgeries to be conducted on time (as scheduled), so the patient is operated much later then planned. There are otherwise only small changes in the parameter in table 13. There is an increase in changing time due to more performed operations and no improvements of planning or delays in the system which also does not reduce the waiting time for the emergency patients.

Added times	Waiting time outside lock	Waiting time locking out	Preparation of operation theatre	Extend finalization	Overtime for personnel
1 hr overtime	-8 %	8 %	12 %	9 %	7 %
2 hr overtime	12 %	10 %	6 %	-1 %	26 %

Table 14: Different delay times before activities, extended finalization due to delays and overtime for personnel.

There is no increase in the patient flow rate (surgeries per hour) and the various delay times and overtime increases (naturally due to allowance of more overtime). One hour overtime reduces somewhat the waiting time outside the locks and the waiting time for the hospital orderly assisting (table 10) in the locking in of patients. This is reasonable since fewer operation theatres are locking in patients during the overtime period and since the hospital orderly have fewer theatres in need of assistance towards the end of the previous shifts. Another reason is that not all of the surgical teams at OT spend overtime every day. That allows for the utilization of shared resources by those teams that do work overtime. But adding one more hour (altogether 2 hours) of overtime allows for more surgical theatres to perform surgeries and adds pressure to the system leading to a significant increase in waiting time (both for a vacant lock and for the hospital orderly – table 14 and 15).

There is an interesting development in the delay caused by waiting for a clean operation theatre and the extended finalization. The more overtime allowed the lesser are these delays. The results needs to be seen in connection with table 15 showing times waiting for a resource to arrive at different activities. The results shows that by locking in patient faster to SOP the patients have to wait longer for a cleaned operation theatre and the pressure on the anaesthetist (table 15) increases leading to extended finalization. The patient are quicker locked in and the preparations starts faster leading also to the patient having to wait for a clean operation theatre (as explained the time it takes to clean an operation theatre is not included in the planed operation program). When the pressure on the locking in activity increases, causing a bigger delay outside the lock, the patients arrives later and the number of patients inn need for an anaesthetist at the same time decreases (table 15). The anaesthetist can therefore arrive more on time at the different activities (finalization and preparation as showed in table 15). In both of the simulation runs there is an increased production and this leads to bigger pressures on the locks locking patients out of SOP and especially on the one lock to the postoperative division leading to a bigger waiting time for this lock to be vacant.

Wait for personnel	Hospital orderly (locking inn)	Hospital orderly (preparations at SOP)	Anaesthetist (preparations at SOP)	Surgeon	Anaesthetist (finalization)
1 hr overtime	-19 %	4 %	2 %	1 %	3 %
2 hr overtime	13 %	9 %	-7 %	5 %	-8 %

Table 15: Delays caused by personnel not arriving at the activity when needed.

Table 15 gives the time used in an activity to wait for different personnel resources – meaning that these resources are needed to complete the activity. By allowing overtime for the anaesthetist leading to a presence of two anaesthetists at the OT section (there are two anaesthetists at the dayshift and one at the evening shift) reduces waiting time for this resources. There is only one hospital orderly during the different shifts so the increase in patients to treat only increases the waiting time (table 15) (except for the one hour locking in activity as explained).

Unused capacity	Cost associated with to idle time	Idle time for personnel	Free surgical theatre time
1 hr overtime	5 %	5 %	4 %
2 hr overtime	11 %	12 %	10 %

Table 16: Results from policy three giving cost and time use which can not be connected to a specific operation type.

It is expected that allowing for overtime increases the idle time because not all of the resources are required throughout the whole surgical procedure (table 16). But the simulation demonstrates that more idle time is spent by the resources on activities un-associated with the surgeries.

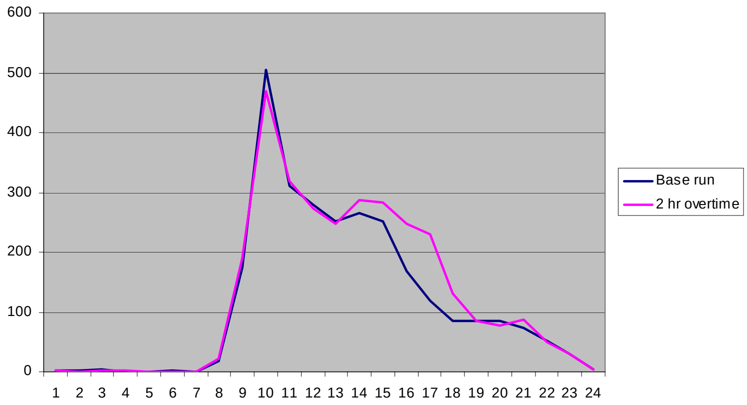

Figure 56: Surgery start-ups

The hypothesis tested states that by allowing for overtime the de-escalation of surgical start-ups will take place later. In fact, the simulation demonstrates that the policy does increase the number of surgical start-ups after lunch and in the simulation that allows for two hours overtime, there is a significant increase in the number of start-ups after lunch compared to the base run (illustrated in figure 56). The run allowing for one hour overtime does also initiate more operations after lunch then the base run model although not as many as the run allowing for two hours.

In summary, by prolonging the amount of time the resources are available (i.e. overtime), there will be an increased production, but no improvement in the overall patient flow rate (surgeries per hour) or utilization of available resources. The policy does delay the de-escalation of surgery start-ups after lunch, causing, as predicted, a diminishing number of cancellations. But the results are not enough to give an overall smoother flow. If performing additional elective operations is the intention, then a two hour overtime policy might be acceptable, but it does not reduce the waiting time for emergency patients (table 13), nor does it prevent the interference between the flows (table 13 - Emergency patients operated at elective theatre).

5.1.5 Policy 4 – nightshift

The Health department in Norway stated in a report in 2001 that the waiting time for surgery for orthopaedic patients at the hospital was long. The hospital got two deviations because of large waiting times for emergency and elective operations. The waiting time was, in the report, assessed to be irresponsible long (Helsetilsynet, 2001). Getting deviations is serious since it is defined as lack of fulfilment of instructions given by the government. The number of emergency orthopaedic patients is much higher then other categories of patients like hart patients. About 70% of all operations performed at OT are performed on emergency patients. For some of the patients a long waiting time can reduce the patient's chances of a full recovery and in some cases threaten the patient's life.

The evening shift at the OT section ends at about eleven o'clock and only acute patients are operated during the night by the operation team on call. The section has one dayshift and one evening shift that only perform emergency operations. The waiting times suggest that this is not enough resources compared to the amount of patients. If an emergency patient has waited past the given emergency degree it is operated at the first vacant operation theatre. This often leads to a disturbance of the elective flow and causes a loss in income for the hospital. The emergency patients also arrive at any hour of the day at the hospital. Considering that there is no team at SOP that constantly operate emergency patients during the night and that emergency patients waits longer then the set degree leading to disturbance of the elective flow, adding more resources to perform operations could be a good solution. The hypothesis formulated to test this assumption is: *a good emergency patient flow is hindered by lack of resources at night.*

The hypothesis is tested by adding an extra shift at the OT section. In the policy there will be three shifts at the operation theatre performing emergency operations; one dayshift, one evening shift and one nightshift. Changes have only been made at the OT section and no other changes have been made than the addition of a nightshift. When there is a nightshift there will not be any operation teams on home duty. Several policy runs will be made and the number of nights during the week, where a nightshift is present will changed for each run. The policy aims at treating emergency patients faster and reducing the waiting time for these patients. By operating the patients faster there is expected less interruption between the emergency and elective flow. In the policy acute patients are still prioritized before other emergency patients that can wait.

Results

The addition of nightshifts gives an excessive reduction in average waiting time for the emergency patients (table 17). The average waiting time in the base run was 27 hours for the emergency patients which are three hours more then the most used emergency degree. Having a nightshift between Monday and Tuesday reduces the waiting time to 20 hours and 30 minuets. Having a nightshift every night of the week (Monday - Friday) brings the average waiting time down to 11 hours. In the table the different runs are identified with the day the nightshift started, Monday (in the table) means that the nightshift started Monday night and ended Tuesday morning when the dayshift arrives and Monday to Friday means that the last nightshift ends Saturday morning.

Changes in patient flow Nightshift	Performed operations	Cancellations	Cost pr operation	Average séance time	Emergency patients operated at elective theatre	Average waiting time for emergency patients	Total time difference between planned and actual surgery start	Average changing time
Monday	5 %	-23 %	-4 %	-1 %	-44 %	-24 %	11 %	-2 %
Monday and Tuesday	7 %	-22 %	-5 %	-1 %	-51 %	-33 %	9 %	5 %
Monday, Tuesday and Wednesday	8 %	-36 %	-6 %	0 %	-67 %	-43 %	17 %	19 %
Monday, Wednesday and Friday	8 %	-29 %	-7 %	-3 %	-76 %	-48 %	8 %	21 %
Monday to Friday	9 %	-33 %	-8 %	-2 %	-81 %	-59 %	18 %	24 %

Table 17: Results from policy four regarding changes in the patient flow.

Further table 17 shows that added resources directed at emergency patients have decreased the interference between the elective and emergency flow and more elective operations are performed (performed operations gives the increase in elective surgeries). The cost pr operation is also reduced even though the extra team is added. This is due to more operations being performed and a reduction in use of home duty. The unit cost has not been changed in the different policies because it is based on the ABC analysis. The extra team is not included in the analysis and my ability to asses the increase of cost is not adequate to asses how much the unit cost would be raised. The focus will therefore be at the other results.

The increase in performed surgeries, leading to reduced cancellations, is mostly due to fewer interactions between the emergency and elective flow (Emergency patients operated at elective theatre in table 17). The changing time is increased because there are not enough emergency patients to fully utilise the added resources (surgery theatre). This, together with a production increase, also is the reason to a bigger time difference between planned and actual surgery start.

There are some small changes in the results when having nightshifts Monday to Wednesday as appose to Monday, Wednesday and Friday. This because having three nightshifts spread out during the week it will give effects that eases the number of emergency patients to treat the next day all through out the week. In the Monday to Wednesday run the effect will, however, decline through out the week.

Changes in patient flow	**Performed operations**			**Cancellation**			**Waiting time outside lock (pr patient)**			**Waiting time locking out**		
Nightshift	Thorax	Head/ Neck	General surgery	Thorax	Head/ Neck	General surgery	Thorax	Head/ Neck	General surgery	Thorax	Head/ Neck	General surgery
Monday	0 %	-1 %	-1 %	-6 %	1 %	0 %	-9 %	-3 %	1 %	4 %	2 %	8 %
Monday and Tuesday	0 %	0 %	-1 %	-2 %	0 %	2 %	-8 %	1 %	0 %	4 %	18 %	5 %
Monday, Tuesday and Wednesday	2 %	1 %	-2 %	-8 %	-2 %	2 %	-7 %	-1 %	2 %	2 %	-2 %	-3 %
Monday to Friday	0 %	2 %	0 %	-6 %	-4 %	0 %	1 %	4 %	8 %	-7 %	5 %	8 %

Table 18: Results from policy four regarding changes in the patient flow from the remaining sections.

The policy does not affect the other sections in a negative way (table 18). The table above shows some of the policy results (there was no big difference in the results from having a nightshift Monday, Tuesday, and Wednesday as to Monday, Wednesday, and Friday). The policy gives little to non change in performed operations and cancellations apart from the Thorax section that have a reduction of cancellations due to more available free locks when locking in (explained below). Only small differences occurred related to uncertainties in the model and due to changes in available locks. There is an added waiting time for locking patients out because of the additional production at the OT section causing a bigger pressure at this lock.

Added times Nightshift	**Waiting time outside lock**	**Waiting time locking out**	**Preparation of operation theatre**	**Extend finalization**	**Overtime for personnel**
Monday	-9 %	17 %	17 %	9 %	17 %
Monday and Tuesday	-10 %	13 %	8 %	6 %	25 %
Monday, Tuesday and Wednesday	-12 %	-2 %	14 %	19 %	19 %
Monday, Wednesday and Friday	-18 %	-2 %	16 %	26 %	34 %
Monday to Friday	-19 %	-4 %	15 %	20 %	14 %

Table 19: Different run results showing delay times before activities, extended finalization and overtime for personnel.

Operating patients at night reduces the pressure on the lock available for locking in patients at the OT section even though there is raised production. The policy seams to also lead to a more accurate patient flow indicated by the raise in the preparation delay, which becomes more evident when there is a better flow. The better predictability is due to less interference between the elective and emergency flow (table 17). If an emergency patient has to be operated at an elective theatre the planed program is stopped. The interference does also sometimes leads to a cancellation of preparation for the next patient that already have started at SOP causing even further delays. The more the surgeries are spread out in time the more is the waiting time for a vacant lock when locking patients out reduced. The increase in production leads to more overtime even though there is less interference between the emergency and elective flow. The lacks in the planed surgery program (tested in policy 2) is another reason for the added overtime. The planed operation time might give the impression that the operation can be performed without causing overtime, but the actual performance times and delays in the system results in use of overtime. A reduction of interference between the elective and emergency flow eases on this issue – given by the least use of overtime if having nightshifts Monday-Friday (table 19).

Wait for personnel Nightshift	Hospital orderly (locking inn)	Hospital orderly (preparations at SOP)	Anaesthetist (preparations at SOP)	Anaesthetist (finalization)
Monday	-27 %	-2 %	-31 %	-13 %
Monday and Tuesday	-30 %	-8 %	29 %	9 %
Monday, Tuesday and Wednesday	-11 %	-18 %	70 %	-2 %
Monday, Wednesday and Friday	-37 %	-55 %	45 %	-9 %
Monday to Friday	-41 %	-61 %	101 %	0 %

*Table 20**:** Delays caused due to late arrival of personnel at the activity.*

A more diverse distribution of patients reduces the waiting time for the hospital orderly (table 20). But, since there is a reduction of anaesthetist at four o'clock from two to one the pressure on this resource increases leading to more waiting time for the specific resource as showed in table 20. The anaesthetist performs activities connected to following up the patient after leaving SOP which again produces more waiting time for this resource when the patient flow increases. As showed in the table the late arrival of the anaesthetist fluctuates in the different runs but an overall increase of late arrivals are evident for this resource. The first run gives a reduction in the waiting time for the anaesthetist. This, seen together with the idle time for personnel in table 21, shows that there are fewer operations to be performed at this night probably due to the queue of emergency patients are reduced during the weekend and during the daytime.

Unused capacity Nightshift	Cost associated with to idle time	Idle time for personnel	Free surgical theatre time
Monday	9 %	10 %	3 %
Monday and Tuesday	21 %	14 %	5 %
Monday, Tuesday and Wednesday	31 %	28 %	8 %
Monday, Wednesday and Friday	32 %	29 %	8 %
Monday to Friday	57 %	50 %	13 %

Table 21: Results from the different runs related to cost and time use which can not be connected to a specific operation type.

The free time for the personnel at the operation team operating emergency patients increases. There might not always be patients to operate because of the prolonging of the shift leading to more idle time. The idle time gives the sum of all idle time spent by the different personnel groups. The personnel groups have different unit costs. Cost associated with idle time is the total cost resulting from idle time for all personnel groups. It is not necessarily that a total increase of 28 % in idle time for personnel will give an equal increase in the costs due to the differences in the unit costs.

The policy leads to a dispersion of the emergency surgeries and performs these procedures faster. The interference between the elective and emergency flow is reduced giving an increased production. The waiting time for the emergency patients does also decrease. But costs and idle time for the personnel rises as more nightshifts are added implying that there might not be enough emergency patients to treat the entire night.

5.1.6 Policy 5 – no planed operations one day a week

Adding extra shifts to operate emergency patients generates overall good results when looking at resource use and patient flow. At the Thorax section one day a week is set of to only operate emergency patients. The policy of having a day with no elective surgery and only operate emergency patients will be tested at the OT section. The policy is a further test of the hypotheses stated in the previous policy but with adding dayshifts instead of having more resources at night.

The base model was adapted to the policy and there will be no planed operation program at Mondays. The operation theatres at the OT section will, on this day, only operate immediate care patients. At the other days of the week there will be one operation theatre set aside to do emergency procedures and the other two to operate elective patients. An anticipated outcome is a reduction in performed elective operations. It is also expected that waiting time for emergency procedures are reduced and a less interference between the planed and unplanned patient flow.

Results

Changes in patient flow	Performed operations	Cancellations	Cost pr operation	Average séance time	Emergency patients operated at elective theatre	Average waiting time for emergency patients	Total time difference between planned and actual surgery start	Average changing time
	-3 %	-21 %	2 %	-1 %	20 %	-1 %	-19 %	-5 %

Table 22: Results from policy five giving the changes in the patient flow.

Table 22 shows that number of performed operations has dropped due to no elective operations on Mondays, but when calculating the average number of performed elective operations pr day there is actually a small increase in number of performed operations from 3, 5 in the base run to 3, 8 in the policy due to more emergency patients are operated on Mondays reducing the interference the next days. The reduction in performed operations without a reduction of resources increases the cost pr operation and there are fewer cancellations due to fewer planed operations. The waiting time for the emergency patients was not reduced much leading to a conclusion that added teams at daytime one day in the week in the week is not enough to give a big reduction in the waiting time for these patients. The other reductions in table 22 are due to less performed operations.

Unused capacity	Cost associated with to idle time	Idle time for personnel	Free surgical theatre time
	9 %	9 %	8 %

Table 23: Idle time and costs for the personnel and unused operation theatre time.

Free time for the personnel increases in the policy because there might not be enough emergency patients to occupy all teams throughout the entire shifts.

The policy did not improve the patient flow. Further tests could have been performed increasing the number of dayshifts held off to operate emergency patients. This might lead to a better flow of emergency patients, but the reduction of the number of elective procedures would have been too big and unrealistic to implement in the real world.

5.1.7 Policy 6 – two operation teams at the evening shift

The hospital describes in a report that lack of resources at the evening shift is a bottleneck in the system due to the reduction of operations starts around one o'clock (Haukeland sykehus, 1998 b). The two former policies show that adding extra shifts operating emergency patients can improve the patient flow, but that shifting resources from elective operations to perform emergency procedures is not the right direction. The hypothesis in policy four states that the bottleneck is due to lack of personnel at night, but that might not be the actual case. Adding more shifts to operate emergency patients in the evening might give similar results.

To further test the hypotheses represented in policy four, one shift is added to the evening shift operating emergency patients from four to eleven o'clock. The two operation teams will, as during the day shift, share one responsible anaesthesia nurse. I have tested whether sharing one nurse or having one pr team gives different results, but the test gave minimal differences. There will be performed several runs of the policy where the number of days a shift is added will vary. Expected results are raise in production, a reduction in waiting time for emergency patients and fewer disturbances between the elective and emergency flow.

Results

The addition of an evening shift results in an increase of performed surgeries and decrease in waiting time for emergency patients (table 24). The number of emergency patients operated at elective theatres increase because the added evening shift operates at one of the elective theatres. Having more then one evening shift leads to a faster emergency flow. The reduction of cancellations together with a raise in performed surgeries show there is less interference between the emergency and elective flow. The increase in production leads to bigger time differences between the planned and actual surgery start and in the changing time.

Changes in patient flow	Performed operations	Cancellations	Cost pr operation	Average séance time	Emergency patients operated at elective theatre	Average waiting time for emergency patients	Total time difference between planned and actual surgery start	Average changing time
Evening shift Monday	3 %	-11 %	-1 %	0 %	10 %	0 %	18 %	3 %
Evening shift Monday and Tuesday	4 %	-10 %	-1 %	-2 %	6 %	-13 %	21 %	8 %
Evening shift Monday, Tuesday and Wednesday	7 %	-19 %	-2 %	-4 %	17 %	-9 %	47 %	14 %
Evening shift Monday, Wednesday and Friday	6 %	-19 %	-1 %	-2 %	23 %	-15 %	48 %	13 %
Evening shift Monday to Friday	6 %	-18 %	-6 %	-6 %	39 %	-23 %	143 %	16 %

Table 24: Results from policy six showing changes in the patient flow at each simulation run.

A more scattering of emergency procedure gives an overall less waiting time for different resources (table 25). By increasing number of emergency procedures performed at the evening there is a reduction of surgeries of these patients at morning freeing more resources. The extra shift also leads to two anaesthetists on the evening which reduces the pressure on this resource giving reduced waiting time. There is however, some added waiting time for the hospital orderly when operating every other day. Increase of operation and more congestion of operation these days' leads to bigger waiting time for arrival of the resource. There is also a raise in waiting time if there are only one or two days with an extra shift due to the same reason and because there is no extra hospital orderly at the evening shift.

Wait for personnel	Hospital orderly (locking inn)	Hospital orderly (preparations at SOP)	Anaesthetist (preparations at SOP)	Anaesthetist (finalization)
Evening shift Monday	5 %	-2 %	-4 %	-5 %
Evening shift Monday and Tuesday	5 %	3 %	-5 %	-10 %
Evening shift Monday, Tuesday and Wednesday	-18 %	0 %	-17 %	-21 %
Evening shift Monday, Wednesday and Friday	15 %	16 %	-30 %	-17 %
Evening shift Monday to Friday	-39 %	-27 %	-44 %	-48 %

Table 25: The results show the late arrival of resources to different activities.

Having evening shifts as opposed to nightshifts does not relive the pressure on the lock (table 26). There are in this policy three operation teams in use of the given lock to the OT section during the day and two teams during the afternoon. An increased production and operation performances within a short time frame increases also the pressure on the lock to the postoperative division making the waiting time rise (table 26). The added anaesthetist reduces the waiting time for the resource and diminishes delays connected to the finalization of the operation. Even though there is a raise in performed surgeries the waiting time for a prepared surgery theatre does not raise much. The patients does not arrive faster to the preparation activity but are delayed outside the lock. Having an evening shift every day of the week the waiting time for a clean operation theatre diminishes because the pressure on the operation theatre is distributed on a bigger time length and there might not be patients to treat all through the shifts.

Added times	Waiting time outside lock	Waiting time locking out	Preparation of operation theatre	Extend finalization	Overtime for personnel
Evening shift Monday	-5 %	24 %	4 %	8 %	0 %
Evening shift Monday and Tuesday	2 %	4 %	0 %	-15 %	-14 %
Evening shift Monday, Tuesday and Wednesday	5 %	11 %	1 %	-10 %	-24 %
Evening shift Monday, Wednesday and Friday	5 %	12 %	1 %	-2 %	-34 %
Evening shift Monday to Friday	10 %	-5 %	-6 %	-25 %	-23 %

Table 26: Waiting times for vacant locks and operation theatres and overtime for personnel.

Similar to the added nightshifts the free time for the personnel increases and so does the time the operation theatre is not in use (table 27) because there might not bee patients to treat all through the length of the shifts. The policy seems to reduce the amount of overtime. But, in the model the dayshift is turned into an evening shift equal as described in the structure assessment test (Team connection and shifts). The ending of a procedure at the operation theatre with an evening shift would therefore not be considered as overtime unless it is ended after eleven o'clock.

Unused capacity	**Cost associated with to idle time**	**Idle time for personnel**	**Free surgical theatre time**
Evening shift Monday	8 %	8 %	7 %
Evening shift Monday and Tuesday	19 %	20 %	18 %
Evening shift Monday, Tuesday and Wednesday	27 %	28 %	26 %
Evening shift Monday, Wednesday and Friday	25 %	27 %	24 %
Evening shift Monday to Friday	53 %	56 %	50 %

Table 27: Cost and time use which can not be connected to a specific operation type resulting form adding an extra evening shift.

By graphing the operations start-ups from one of the policy runs together with the base run results one can see that there are more operations performed in the evening. This gives a slight reduction in number of surgery start-ups in the morning due to more being operated the previously evening.

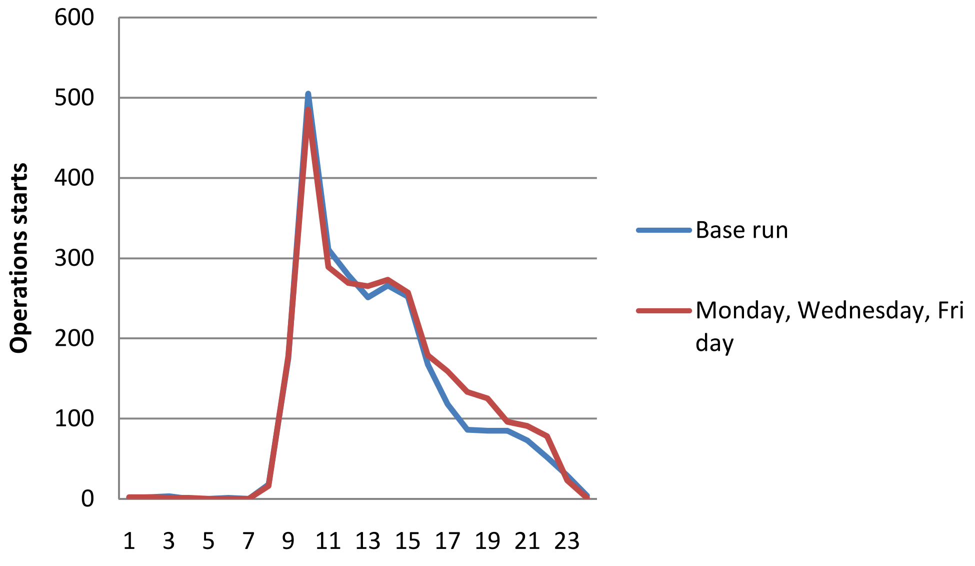

Figure 57: Operation starts base run vs. evening shifts.

The addition of the evening shifts does improve the patient flow and reduces the waiting time for emergency patients. There is also more freed resource during the dayshift reducing delays for available resources.

5.1.8 Policy 7 – added resources

Former policies have indicated that reducing delays by having resources available when needed, can improve the flow due to reduced delays. In a report the hospital states that waiting time for anaesthetist is considered to be a bottleneck in the system, particularly in the morning. And there are raised questions if whether more anaesthetists can help improve the patient flow (Haukeland sykehus, 1998 b). Some of the policies have also shown that increased production leads to bigger pressure on the personnel resources. Delays due to unavailable personnel in the system have lead to the hypotheses that; *A non optimal patient flow is due to lack of personnel causing a bottleneck in the system.*

The hypothesis is test by running three policy runs; in the first run an extra anaesthetist is added to the model, in the second run a hospital orderly and in the third run an anaesthesia nurse. The addition of resources will be tested at the OT section.

The thorax section has more resources then the OT section and will therefore not be tested but will be equivalent with the base run. The extra resources will only work on the dayshift when the patient flow is at its biggest. Expected results are reduction in waiting time for the different resources leading to a smaller séance time due to fewer delays at SOP. A cost increase is also expected.

Results

The addition of single resources gives only small changes in the patient flow (table 28). There have nevertheless been small reductions of waiting time for emergency patients and a reduction of emergency patients being operated at elective theatres, meaning that the emergency flow has improved some. The reduction of emergency patients operated at elective theatres also leads to a decrease in cancellations in the two first runs. The addition of an anesthesia nurse gives only small differences to the flow due to small changes in performance of the operations. There is some reductions in the time difference between the planed and actually surgery start and changing time. The added cancellation is small and considered insignificant. Since there is not operated more patients the additional resource leads to an increase in costs.

Changes in patient flow	Performed operations	Cancellations	Cost pr operation	Average séance time	Emergency patients operated at elective theatre	Average waiting time for emergency patients	Total time difference between planned and actual surgery start	Average changing time
Anaesthetist	1 %	-8 %	-1 %	0 %	-13 %	-9 %	7 %	2 %
Hospital orderly	2 %	-10 %	-1 %	-2 %	-9 %	-3 %	3 %	1 %
Anesthesia nurse	0 %	2 %	3 %	1 %	-6 %	-3 %	-7 %	-2 %

Table 28: Changes in the patient flow by adding resources too the OT section.

One extra hospital orderly does reduce the waiting time outside the lock due patient being faster locked in (table 29) because of reduced waiting time for the resource (table 30). The small increase in production in the run rises the waiting time for a vacant lock. By locking in patients faster the extended finalization increases due to the next patient is ready to be operated before the finalization is completed.

Added times	Waiting time outside lock	Waiting time locking out	Preparation of operation theatre	Extend finalization	Overtime for personnel
Anaesthetist	-2 %	8 %	1 %	-2 %	7 %
Hospital orderly	-8 %	8 %	0 %	14 %	-12 %
Anesthesia nurse	2 %	5 %	6 %	5 %	-7 %

Table 29: Time resulting from waiting for available resources and overtime for the personnel

The time spent waiting for the anaesthetist and hospital orderly are accumulated. The anaesthesia nurses are in many cases the resource needed for the activity to be initiated. The patient has to be called down to SOP by an anaesthesia nurse and when locked in and prepared the nurse stays with the patient. An extra nurse does not lead to a smaller waiting time outside the lock which indicates that the lack of nurses is not the reason for delays caused for the patient outside SOP. The waiting time for a operation theatre and for the finalization to end increases giving that the preparation of a patients are performed a bit faster with one extra nurse (table 29). A faster preparation leads to added waiting time for the anaesthetist (table 30). The addition of an anaesthetist does not lead to less overtime as in the other runs. The overtime increase is not large and is probably related to the increase in production without a reduction in the séance time (table 28).

Wait for personnel	Hospital orderly (locking inn)	Hospital orderly (preparations at SOP)	Anaesthetist (preparations at SOP)	Anaesthetist (finalization)
Anaesthetist	13 %	18 %	-46 %	9 %
Hospital orderly	-88 %	-43 %	-3 %	-2 %
Anesthesia nurse	-7 %	11 %	10 %	0 %

Table 30: Delays due to late arrival of personnel at the activity.

As illustrated in table 30 there is a reduction in the delays caused by late arrival of the different resources when there is added extra resources. There is a small increase in waiting for an anaesthetist at the finalization activity in the first run, but this increase is small and mostly due to a smoother patient flow increasing the need for the resource at several activities at the same time. Patients arrive faster at the preparation room and the preparation starts faster which leads to a need for the anaesthetist to arrive sooner.

Adding extra resources does lead to more free time and cost connected to the free time (table 31). Having an extra anaesthesia nurse does not give large improvements on the patient flow in the model which might indicate that the organisation of the nurses is good and does not hinder the patient flow.

Unused capacity	Cost associated with to idle time	Idle time for personnel	Free surgical theatre time
Anaesthetist	5 %	17 %	1 %
Hospital orderly	3 %	11 %	2 %
Anesthesia nurse	21 %	3 %	2 %

Table 31: Cost and time use which can not be connected to a specific operation type - results from policy 7.

The given results show that adding single resources do, at some personnel groups, lead to a reduction of delays caused by missing personnel. Some resources do not hinder the patient flow leading to the idea that there might not be a need for additions of all personnel groups. Simulation runs might give an idea of which personnel groups that are well organised and which that need to be strengthen. But the results also show that the addition of one resource only produce small changes in the flow.

5.1.9 Policy 8 – added postoperative beds

Postoperative division beds are shared between the OT, Head/Neck and General surgery sections. Thorax is the only section that has a separate Thorax postoperative division. One reason as to why operations are cancelled is lack of available beds at the postoperative division. Surgeries, leading to a patient in need of a postoperative bed, can not be performed unless there is a vacant bed at the postoperative division. A report from the Health department states that there is a marginal capacity at the postoperative division which at times leads to cancellation of operations. The report further states that an eventual increase in production at SOP will contribute to a need for capacity expansion at the postoperative division (Helsetilsynet, 2001). If the amount of beds reduces the patient flow it can be a reason for a non optimal usage of resources at SOP, a bottleneck in the system leading to the hypotheses that: *Bottlenecks caused by lack of resources outside SOP constrains the patient flow through SOP.*

Five beds have been added to the shared postoperative division, the model used in the policy is otherwise equivalent with the base model. The policy is expected to affect the OT, Head/Neck and General surgery section since patients from these sections are sent to the postoperative division. If it turns out to be a bottleneck in the system the added beds is expected to increase the patient flow and to give a better utilisation of the resources at SOP.

Results

The OT section gets the best utilisation of the bed increase. More operations are performed and the changing time reduction of 15 % means an increased predictability in the flow (table 32). Less emergency patients are operated at elective theatres without increasing the waiting time. If a patient is in need of a postoperative bed it can not be operated unless there is a free bed at the postoperative division. Having more beds at the division results in a faster patient flow and reduces the waiting time for emergency patients. The better flow also gives a reduction in the changing time. An increase in performed elective surgeries leads to bigger differences between planned and actual surgery starts because some of the operations that where before cancelled are now performed (32).

Changes in patient flow	Performed operations	Cancellations	Cost pr operation	Average séance time	Emergency patients operated at elective theatre	Average waiting time for emergency patients	Total time difference between planned and actual surgery start	Average changing time
OT	4 %	-17 %	-2 %	0 %	-23 %	-15 %	9 %	-15 %
Thorax	1 %	-3 %	0 %	-4 %	*	4 %	5 %	2 %
Head/Neck	2 %	-6 %	*	2 %	*	4 %	6 %	6 %
General surgery	2 %	-7 %	*	1 %	*	-2 %	-12 %	3 %

Table 32: Results from the eight policy regarding changes in the patient flow (Not applicable).*

Results from the other sections show only small changes (table 32) illustrating that the OT section is in most need of postoperative beds compared to the number of patients operated at this section. The improvements at the OT section are connected to the many emergency patients in need of postoperative beds and that these are faster treated. But there are also some improvements at the General surgery section illustrating that it are not only the OT section that is in need for extra beds at the postoperative division.

Added times	Waiting time outside lock	Waiting time locking out	Preparation of operation theatre	Extend finalization	Overtime for personnel
OT	-1 %	19 %	10 %	22 %	8 %
Thorax	11 %	5 %	4 %	21 %	
Head/ Neck	4 %	20 %	*	*	
General surgery	8 %	10 %	*	*	

Table 33: Results from the policy run giving the waiting time for available resources and overtime for the personnel (only for sections with personnel models).*

When more patients are operated the pressure on the locks increases. The Thorax section is the only section without a specific lock when locking patients in to SOP and the added performed operations increase the waiting time for Thorax patients because they have to wait until the other sections have locked in their patients. The waiting time for an available lock when locking patients in to SOP at the OT section is more close to the base run results due to the increase in postoperative bed dispersing the arrival of patients at SOP more during the day. With more patient flowing to the postoperative division the waiting time for a free lock out of SOP is increased (table

33). The opening of the bottleneck has lead to an increased utilisation of resources, both personnel and surgical theatres (table 34). More available beds give a smoother flow and reduce waiting time for patient arrival due to more vacant beds at postoperative division.

Unused capacity	Cost associated with to idle time	Idle time for personnel	Free surgical theatre time
OT	-4 %	-3 %	-5 %

Table 34: An increase in beds leads to a reduction in cost and time use which can not be connected to a specific operation type.

There are only small changes in waiting time for available personnel. The waiting time for the anaesthetist is reduced and is therefore not the reason for the prolonged finalization at the OT section (table 33). But, when having a more reliable program an increased finalization becomes more visible when the predictability in the flow is increased. The anaesthetist is more on time because the arrival of patients during the day is more dispersed and less disturbed by lack of vacant postoperative beds.

Wait for personnel	Hospital orderly (locking inn)	Hospital orderly (preparations at SOP)	Anaesthetist (preparations at SOP)	Surgeon	Anaesthetist (finalization)
Added postoperative beds	1 %	8 %	-7 %	1 %	-10 %

Table 35: Delays caused by late arrival of personnel at the activity.

The results from the policy gives the impression of that number of beds at the postoperative division can at times be a bottleneck in the system. The bottleneck does however affect some sections more then others. Reducing the bottleneck gives a positive outcome on the patient flow and resource utilisation at the OT section.

5.1.10 Policy 9 - starting time for calling of patients

One bottleneck in the system is the locks which is the first stand getting into SOP. In the base run the total waiting time for Orthopaedic patients outside the locks was about 270 hours. Dividing the time pr. patient gives a waiting time of about 6 minutes pr patient which is not that much. The problem is that the bottleneck is most visible in the morning when the sections, with very little time difference, call their patients to SOP. Dividing the waiting time on the total number of patients does therefore not give a correct presentation of the problem. The patients needs to wait outside SOP for a vacant lock and which can delay the operation start because of late arrival of the patient to the preparation. The delayed start-up can further delay the rest of the patient treatment and the next patients' arrival. The results from some of the policies show that an increase in the flow produces more waiting time for the patient outside the locks. The described problem leads to the hypotheses: *lack of free locks creates a bottleneck that leads to an un-optimal patient flow caused by lack of utilisation of resources.*

In the base run model the sections start calling their patients to SOP within a very short time differences. Thorax starts at about 07:40 AM, Head/Neck and General surgery at 07:45 AM and the Orthopaedic section at 07:50 AM. In this policy the different sections calling time in the morning is changed. There are three locks and each section is given 10 minutes to lock in a patient, meaning sections that use three operation theatres have 10 minutes to lock in their patients before other sections patients arrive. Sections having six operation theatres are given 20 minutes to lock in their group of patients in the morning. The Thorax section starts at seven o'clock followed by the Orthopaedic section ten minuets later. Head/Neck calls their patients to SOP ten minutes after OT and then after 20 minuets General surgery starts calling their patients to SOP. The starting and ending time of the different personnel shifts have been adjusted according to the calling time - giving the same shift length as in the base run. At the OT section the operation nurses will start at the same time as the anaesthesia nurses which differences from the Base Run where they arrive later. This is done because there is only one hospital orderly at the section and the operation nurses therefore have to help the patients under the locking activity when the hospital orderly is occupied. The different locks are also open and the sections use the first available lock. If there are several patients waiting for a vacant lock the patient that have waited the longest gets locked in first.

Expected results are a reduction in accumulations of patients outside the locks and operations start closer to the planed time. The policy will free the locks making it possible for the different sections to lock inn more patients at the same time. It is also possible that the policy will decrease the amount of waiting time for locking patients out of SOP and into the postoperative division because the different time intervals calling patients to SOP will result in a corresponding finishing time of the different operations.

Results

The policy did meet all of the expected results (table 36). There where almost no change in the amount of operations being performed at the different sections, but the policy did reduce the discrepancy between the planed operation start and the actual operation start. The results also show small changes at the different sections but there is no consistency in the results which could have implicated a better flow. The changes are regarded as small and not significant enough to lead to any conclusion of an overall improvement (table 36).

Changes in patient flow	Performed operations	Cancellations	Cost pr operation	Average séance time	Emergency patients operated at elective theatre	Average waiting time for emergency patients	Total time difference between planned and actual surgery start	Average changing time
OT	1 %	-4 %	0 %	-1 %	-10 %	0 %	-6 %	3 %
Thorax	0 %	6 %	3 %	-5 %	*	3 %	-6 %	-4 %
Head/Neck	2 %	-5 %	*	-1 %	*	0 %	-3 %	3 %
General surgery	0 %	-1 %	*	2 %	*	5 %	-6 %	6 %

Table 36: Changes in the patient flow by changing the locking policy (Not applicable).*

Looking at the unused capacity at the OT section there is an increase of cost and free time while at Thorax has a small drop (table 37). There is a better utilisation of the resources meaning the section operates an equal amount of operations but utilises the resources better and decreases the use of overtime (table 38). A change of policy does give some ripple effects in the model which can for instance give change in parameter values given in the model. This have in this run changed the number of emergency patients that where operated at the Thorax section. These patients have in the base run arrived at the hospital but where in line for an operations that there where not enough time to perform. This explains the increase in cancellations without a decrease in production.

The policy does not give a better utilisation of the personnel at the OT section but and increase in idle time due to an increase in waiting time for the different patients to arrive at SOP.

Unused capacity	Cost associated with to idle time	Idle time for personnel	Free surgical theatre time
OT	5 %	5 %	4 %
Thorax	-2 %	-6 %	1 %

Table 37: Results from the policy giving cost and time use which can not be connected to a specific operation type.

Waiting time outside the locks is reduced for two of the sections (table 38), but the delay due to waiting for a free lock out of SOP is increased at all of the sections. By opening up the locks the sections with most operation theatres get less waiting time for the patients when locking them in. Before these sections had to lock their patient through one lock, but getting increased time in the morning and access to more locks, the waiting time for the patient improves. The policy shows that the different sections patient flows interfere more with each other if the locks are opened up. The sections with fewest surgery theatres are affected in a negative way even though they get more available locks in the morning due to more interference from the other sections patient flow. When the sections locks in more patients at the same time patients needs to wait longer before they are locked out of SOP. It seems like that starting operations within a section more on time (table 36), having several operation start-ups at the same time makes the operations end more simultaneously leading to more patients in need of a lock within the shorter time period.

Added times	Waiting time outside lock	Waiting time locking out	Preparation of operation theatre	Extend finalization	Overtime for personnel
OT	15 %	7 %	-6 %	-8 %	11 %
Thorax	47 %	33 %	-1 %	13 %	-18 %
Head/Neck	-40 %	22 %			
General surgery	-23 %	11 %			

Table 38: Delays due to waiting for free resources (locks, operation theatres) and overtime for personnel

The policy attends to open up the bottleneck by changing the starting time for calling the first patient down to SOP. The expected results are not meet and the patient flow was not improved. There is also a larger pressure when locking a patient out of SOP without a correspondingly increase in the production.

5.2 Summary of policy results

The different policies aims at testing hypothesis directed at bottlenecks or obstructions which are reasons for a sub-optimal utilization of resources and inefficient patient flow. Some of the bottlenecks have larger influences on the system then others and resolving them gives better overall results on the flow. By seeing the different policy results up against each other I aim at finding the policies giving the best overall result at the OT section that does not affect the other sections in a negative matter.

The highest production increase was achieved through allowing overtime and adding extra shifts at night (table 39). Applying single personnel resources and opening locks resulted in (apart from reducing number of days elective surgeries are performed) the lowest increase in production.

Changes in patient flow	Performed operations	Cancellations	Cost pr operation	Average séance time	Emergency patients operated at elective theatre	Average waiting time for emergency patients	Total time difference between planned and actual surgery start	Average changing time
Policy 1 - Decreasing delays	3 %	-8 %	-4 %	-6 %	-12 %	-2 %	3 %	8 %
Policy 2 - Improve operation planning	3 %	-44 %	-11 %	-3 %	-23 %	-11 %	-2 %	-15 %
Policy 3 - 1 hr overtime	5 %	-13 %	-3 %	1 %	-1 %	2 %	32 %	5 %
Policy 3 - 2 hr overtime	9 %	-37 %	-3 %	-2 %	5 %	4 %	73 %	9 %
Policy 4 - Nightshift Monday	5 %	-23 %	-4 %	-1 %	-44 %	-24 %	11 %	-2 %
Policy 4 - Nightshift Monday to Friday	9 %	-33 %	-8 %	-2 %	-81 %	-59 %	18 %	24 %
Policy 4 - Nightshift Monday, Wednesday and Friday	8 %	-29 %	-7 %	-3 %	-76 %	-48 %	8 %	21 %
Policy 4 - Nightshift Monday, Tuesday and Wednesday	8 %	-36 %	-6 %	0 %	-67 %	-43 %	17 %	19 %
Policy 4 - Nightshift Monday and Tuesday	7 %	-22 %	-5 %	-1 %	-51 %	-33 %	9 %	5 %
Policy 5 - No planed operations one day a week	-4 %	-23 %	3 %	-1 %	22 %	6 %	-20 %	0 %
Policy 6 - Evening shift Monday	3 %	-11 %	-1 %	0 %	10 %	0 %	18 %	3 %
Policy 6 - Evening shift Monday and Tuesday	4 %	-10 %	-1 %	-2 %	6 %	-13 %	21 %	8 %
Policy 6 - Evening shift Monday to Friday	6 %	-18 %	-6 %	-6 %	39 %	-23 %	143 %	16 %
Policy 6 - Evening shift Monday, Wednesday and Friday	6 %	-19 %	-1 %	-2 %	23 %	-15 %	48 %	13 %
Policy 6 - Evening shift Monday, Tuesday and Wednesday	7 %	-19 %	-2 %	-4 %	17 %	-9 %	47 %	14 %
Policy 7 - One extra anesthesia nurse	0 %	2 %	3 %	1 %	-6 %	-3 %	-7 %	-2 %
Policy 7 - One extra anaesthetist	1 %	-8 %	-1 %	0 %	-13 %	-9 %	7 %	2 %
Policy 7 - One extra hospital orderly	2 %	-10 %	-1 %	-2 %	-9 %	-3 %	3 %	1 %
Policy 8 - Added postoperative beds	4 %	-17 %	-2 %	0 %	-23 %	-15 %	9 %	-15 %
Policy 9 - Changed starting time	1 %	-4 %	0 %	-1 %	-10 %	0 %	-6 %	3 %

Table 39: Patient flow results from all of the policies where number outlined in blue are the best parameter results.

An improved planning of the operation program almost halved cancelled surgeries. Adding more shifts also reduced cancellation though in a different matter then the previous mentioned policy. An operation program in it self does not improve the flow, it's the resources ability to perform the program as planed that leads to an improvement. And a more reliable program eases the job for the personnel resources. The addition of shifts affects the cancellation by treating emergency patients faster and reducing interference with the elective flow. Another good effect of better planning is a cost reduction, but adding personnel is only cost effective if there is a good increase in production (table 39).

An exogenous element which interacts with the system can inflict the system with added delays and through this raise the average séance time (delayed surgeon). Reducing the delayed improves the patient flow (table 39). Adding shifts, relieving the dayshifts, reduce the waiting time for the patient to arrive at SOP due to a dispersion of emergency patients throughout the day (table 40 – reduction in waiting time outside locks). Policies that direct more resources (personnel and operation theatres) at emergency patients, reduce the interference between elective and emergency treatment (table 39) and at the same time lead to a reduction of waiting time getting the patient faster through the system (table 39 and 40). Allowing for more overtime, however, is not enough to get emergency patients quicker treated – bur reduces the cancellations.

Table 39 shows that few of the policies lead to a reduction of the discrepancy between planed and actual operation start. The increase in discrepancy that occurs when adding shifts at the evening is due to surgery of the "last" elective patient that otherwise would have been cancelled. Changing time is improved by adding postoperative beds and better planning.

Added times	Waiting time outside lock	Waiting time locking out	Preparation of operation theatre	Extend finalization	Overtime for personnel
Policy 1 - Decreasing delays	4 %	9 %	-7 %	-16 %	-7 %
Policy 2 - Improve operation planning	1 %	8 %	46 %	61 %	-19 %
Policy 3 - 1 hr overtime	-8 %	8 %	12 %	9 %	7 %
Policy 3 - 2 hr overtime	12 %	10 %	6 %	-1 %	26 %
Policy 4 - Nightshift Monday	-9 %	17 %	17 %	9 %	17 %
Policy 4 - Nightshift Monday to Friday	-19 %	-4 %	15 %	20 %	14 %
Policy 4 - Nightshift Monday, Wednesday and Friday	-18 %	-2 %	16 %	26 %	34 %
Policy 4 - Nightshift Monday, Tuesday and Wednesday	-12 %	-2 %	14 %	19 %	19 %
Policy 4 - Nightshift Monday and Tuesday	-10 %	13 %	8 %	6 %	25 %
Policy 5 - No planed operations one day a week	-5 %	0 %	-10 %	-17 %	-8 %
Policy 6 - Evening shift Monday	-5 %	24 %	4 %	8 %	0 %
Policy 6 - Evening shift Monday and Tuesday	2 %	4 %	0 %	-15 %	-14 %
Policy 6 - Evening shift Monday to Friday	10 %	-5 %	-6 %	-25 %	-23 %
Policy 6 - Evening shift Monday, Wednesday and Friday	5 %	12 %	1 %	-2 %	-34 %
Policy 6 - Evening shift Monday, Tuesday and Wednesday	5 %	11 %	1 %	-10 %	-24 %
Policy 7 - One extra anesthesia nurse	2 %	5 %	6 %	5 %	-7 %
Policy 7 - One extra Anaesthetist	-2 %	8 %	1 %	-2 %	7 %
Policy 7 - One extra hospital orderly	-8 %	8 %	0 %	14 %	-12 %
Policy 8 - Added postoperative beds	-1 %	19 %	10 %	22 %	8 %
Policy 9 - Changed starting time	15 %	7 %	-6 %	-8 %	11 %

Table 40: Waiting times for available locks and operation theatres and additional overtime for the different policies where number outlined in blue are the best parameter results.

The table above shows that reduction of pressure on the locks is best achieved by spreading out the procedures relieving the pressure during the day time when most operation theatres are in use. Less interference in the patient flow combined with an increased production gives a raise in waiting time for a cleaned operation theatre. This might be improved by taking the time it takes to clean an operation theatre into consideration when planning the operation program. By planning better delays caused by prolonged operations or finalizations becomes more evident. Adding a shift with an extra anaesthetist and having available personnel is one way of reducing the delay.

The different runs show that the only way to reduce time spent waiting for personnel is to add more resources (table 41). Adding single resources gives good results on the waiting times, but the overall improvements of the flow and waiting time is to add entire shifts.

Wait for personnel	**Hospital orderly (locking inn)**	**Hospital orderly (preparations at SOP)**	**Anaesthetist (preparations at SOP)**	**Anaesthetist (finalization)**
Policy 1 - Decreasing delays	-13 %	9 %	13 %	3 %
Policy 2 - Improve operation planning	-24 %	-51 %	2 %	12 %
Policy 3 - 1 hr overtime	-19 %	4 %	2 %	3 %
Policy 3 - 2 hr overtime	13 %	9 %	-7 %	-8 %
Policy 4 - Nightshift Monday	-27 %	-2 %	-31 %	-13 %
Policy 4 - Nightshift Monday to Friday	-41 %	-61 %	101 %	0 %
Policy 4 - Nightshift Monday, Wednesday and Friday	-37 %	-55 %	45 %	-9 %
Policy 4 - Nightshift Monday, Tuesday and Wednesday	-11 %	-18 %	70 %	-2 %
Policy 4 - Nightshift Monday and Tuesday	-30 %	-8 %	29 %	9 %
Policy 5 - No planed operations one day a week	29 %	1 %	17 %	-6 %
Policy 6 - Evening shift Monday	5 %	-2 %	-4 %	-5 %
Policy 6 - Evening shift Monday and Tuesday	5 %	3 %	-5 %	-10 %
Policy 6 - Evening shift Monday to Friday	-39 %	-27 %	-44 %	-48 %
Policy 6 - Evening shift Monday, Wednesday and Friday	15 %	16 %	-30 %	-17 %
Policy 6 - Evening shift Monday, Tuesday and Wednesday	-18 %	0 %	-17 %	-21 %
Policy 7 - One extra anesthesia nurse	-7 %	11 %	10 %	0 %
Policy 7 - One extra anaesthetist	13 %	18 %	-46 %	9 %
Policy 7 - One extra hospital orderly	-88 %	-43 %	-3 %	-2 %
Policy 8 - Added postoperative beds	1 %	8 %	-7 %	-10 %
Policy 9 - Changed starting time	21 %	11 %	-1 %	-19 %

Table 41: The results from the policies concerning late arrival of resources to different activities where number outlined in blue are the best parameter results.

But increasing number of shifts also leads to more idle time (table 42). Even though overtime is reduced by having evening shifts relieving dayshifts the idle time for personnel and surgical theaters are increased. Both improved planning and opening the bottleneck of available beds at postoperative division reduce the unused capacity. The lack of available beds hinders the commencement of surgeries leading to operation theatres standing empty. Increasing the number of beds improves the use of surgical theatres (table 42).

Unused capacity	Cost associated with to idle time	Idle time for personnel	Free surgical theatre time
Policy 1 - Decreasing delays	6 %	6 %	10 %
Policy 2 - Improve operation planning	-2 %	-2 %	-1 %
Policy 3 - 1 hr overtime	5 %	5 %	4 %
Policy 3 - 2 hr overtime	12 %	11 %	10 %
Policy 4 - Nightshift Monday	9 %	10 %	3 %
Policy 4 - Nightshift Monday to Friday	57 %	29 %	13 %
Policy 4 - Nightshift Monday, Wednesday and Friday	32 %	50 %	8 %
Policy 4 - Nightshift Monday, Tuesday and Wednesday	31 %	28 %	8 %
Policy 4 - Nightshift Monday and Tuesday	21 %	14 %	5 %
Policy 5 - No planed operations one day a week	12 %	12 %	10 %
Policy 6 - Evening shift Monday	8 %	8 %	7 %
Policy 6 - Evening shift Monday and Tuesday	19 %	20 %	18 %
Policy 6 - Evening shift Monday to Friday	53 %	56 %	50 %
Policy 6 - Evening shift Monday, Wednesday and Friday	25 %	27 %	24 %
Policy 6 - Evening shift Monday, Tuesday and Wednesday	27 %	28 %	26 %
Policy 7 - One extra anesthesia nurse	21 %	3 %	2 %
Policy 7 - One extra anaesthetist	5 %	17 %	1 %
Policy 7 - One extra hospital orderly	3 %	11 %	2 %
Policy 8 - Added postoperative beds	-4 %	-3 %	-5 %
Policy 9 - Changed starting time	5 %	5 %	4 %

Table 42: Results form the different policies giving cost and time use which can not be connected to a specific operation type where number outlined in blue are the best parameter results.

5.3 Combining policies

The different policies are directed at different bottlenecks. I will her combine some of the policies to see if a combination of policies aiming at different bottlenecks or obstructions together can lead to a good flow by utilizing available resources better then what they did individually. I have selected five policies and combined them. The model is run for each addition of a policy and the results are represented below. I will give a short discussion of the most interesting results from the combination of the policies which are shown in a percentage difference to the base run results.

The first combination is reduction of exogenous delays and a better planning of the surgery program. Each by them self gave an increase of 3 % in performed operations. In combination the number of performed operation has grown to 6 % (table 43). The results from the run are almost equal to adding the result for the two tests by themselves. The two policies aims at solving different problems and does therefore not offset results from the other. Added times have increased due to none of the policy being directed directly at the patient flow (table 44). There is an increase of waiting for personnel but a reduction of overtime. The two policies combined utilize the resources better by increasing production without increasing the overtime but not all of the available time caused by these two policies are used due to more free time (table 45). The increase in number of performed surgeries increases the pressure on presence of resources and on the locks (table 44 and 46).

Changes in patient flow	Performed operations	Cancellations	Cost pr operation	Average séance time	Emergency patients operated at elective theatre	Average waiting time for emergency patients	Total time difference between planned and actual surgery start	Average changing time
Policy 1 and 2	6 %	-55 %	-7 %	-5 %	-37 %	-19 %	2 %	-3 %

Table 43: Patient flow results from combining policy 1 and 2

Added times	Waiting time outside lock	Waiting time locking out	Preparation of operation theatre	Extend finalization	Overtime for personnel
Policy 1 and 2	6 %	9 %	34 %	49 %	-18 %

Table 44: Added times results from combining policy 1 and 2

Unused capacity	Cost associated with to idle time	Idle time for personnel	Free surgical theatre time
Policy 1 and 2	4 %	5 %	7 %

Table 45: Unused capacity results from combining policy 1 and 2

Waiting for personnel	Hospital orderly (locking inn)	Hospital orderly (preparations at SOP)	Anaesthetist (preparations at SOP)	Anaesthetist (finalization)
Policy 1 and 2	28 %	12 %	4 %	9 %

Table 46: Time spent waiting for personnel to arrive at activities from combining policy 1 and 2

The third policy combined with the two mentioned is adding shifts at night (Monday, Tuesday and Wednesday). Having five shifts resulted in a lot of free time for the personnel in addition to overtime and increased costs that can't be connected to an specific operation type. I have therefore chosen the policy run with three nightshifts (Monday – Wednesday).

By itself the policy raised production with 8 % and in combination with the two others the total production increased 10% (table 47). It is not expected to get the same growth as the first run because due to a better operation program the elective flow is already improved. The policy addition does however result in a 74 % reduction in number of emergency patients operated at elective theatres and a 52 % reduction of waiting time (table 47). The outcome also shows a reduced waiting time for personnel resources but again the increase in resources does lead to added free time and costs (table 49). There is a raise in waiting time for the anaesthetist to arrive at the preparation due to a more reliable operation program and improved inflow through the locks (table 48 and 3).

Changes in patient flow	Performed operations	Cancellations	Cost pr operation	Average séance time	Emergency patients operated at elective theatre	Average waiting time for emergency patients	Total time difference between planned and actual surgery start	Average changing time
Policy 1 and 2	6 %	-55 %	-7 %	-5 %	-37 %	-19 %	2 %	-3 %
Policy 1, 2 and 4	10 %	-63 %	-9 %	-7 %	-74 %	-52 %	7 %	8 %

Table 47: Patient flow results from combining policy 1, 2 and 4

Added times	Waiting time outside lock	Waiting time locking out	Preparation of operation theatre	Extend finalization	Overtime for personnel
Policy 1 and 2	6 %	9 %	34 %	49 %	-18 %
Policy 1, 2 and 4	-10 %	5 %	47 %	37 %	0 %

Table 48: Added times results from combining policy 1, 2 and 4

Waiting for personnel	Hospital orderly (locking inn)	Hospital orderly (preparations at SOP)	Anaesthetist (preparations at SOP)	Anaesthetist (finalization)
Policy 1 and 2	28 %	12 %	4 %	9 %
Policy 1, 2 and 4	-1 %	-18 %	29 %	-1 %

Table 49: Time spent waiting for personnel to arrive at activities from combining policy 1, 2 and 4

Unused capacity	Cost connected to free time	Free time for personnel	Free operation theatre time
Policy 1 and 2	4 %	5 %	7 %
Policy 1, 2 and 4	38 %	35 %	17 %

Table 50: Unused capacity results from combining policy 1, 2 and 4

The increase of postoperative beds did not have the biggest impact on the patient flow but did lead to better resource utilization. By adding this policy to the others one could expect an even smoother flow and better resource use. In the table 50 one sees that in the patient flow there is a little improvement. It might seem like the dispersion of operations have reduced the effect that occurred when adding more postoperative beds (policy 8).

The waiting time for personnel has, by adding more beds, increased for the anaesthetist (table 53). A bigger inflow and reduced waiting time outside the locks have lead to a bigger need for anaesthetists to be on time for the preparation activity. Delays caused by finalizations taking longer then planed have become more visible through the combination of the different policies (table 51).

Changes in patient flow	Performed operations	Cancellations	Cost pr operation	Average séance time	Emergency patients operated at elective theatre	Average waiting time for emergency patients	Total time difference between planned and actual surgery start	Average changing time
Policy 1 and 2	6 %	-55 %	-7 %	-5 %	-37 %	-19 %	2 %	-3 %
Policy 1, 2 and 4	10 %	-63 %	-9 %	-7 %	-74 %	-52 %	7 %	8 %
Policy 1, 2, 4 and 8	11 %	-65 %	-9 %	-6 %	-71 %	-52 %	2 %	9 %

Table 51: Patient flow results from combining policy 1, 2, 4 and 8

Added times	Waiting time outside lock	Waiting time locking out	Preparation of operation theatre	Extend finalization	Overtime for personnel
Policy 1 and 2	6 %	9 %	34 %	49 %	-18 %
Policy 1, 2 and 4	-10 %	5 %	47 %	37 %	0 %
Policy 1, 2, 4 and 8	-1 %	9 %	47 %	43 %	-4 %

Table 52: Added times results from combining policy 1, 2, 4 and 8

Unused capacity	Cost connected to free time	Free time for personnel	Free operation theatre time
Policy 1 and 2	4 %	5 %	7 %
Policy 1, 2 and 4	38 %	35 %	17 %
Policy 1, 2, 4 and 8	36 %	32 %	15 %

Table 53: Unused capacity results from combining policy 1, 2, 4 and 8

Waiting for personnel	Hospital orderly (locking inn)	Hospital orderly (preparations at SOP)	Anaesthetist (preparations at SOP)	Anaesthetist (finalization)
Policy 1 and 2	28 %	12 %	4 %	9 %
Policy 1, 2 and 4	-1 %	-18 %	29 %	-1 %
Policy 1, 2,4 and 8	13 %	-20 %	81 %	9 %

Table 54: Waiting time for personnel results from combining policy 1, 2, 4 and 8

It might be that lack of personnel like hospital orderly and anaesthetist stops the policy of additional beds reaching its full potential. By adding the mentioned resources in the last addition of policies the production improves with 13 % compared to the bas run results (table 52). Except for a good reduction in cancellation there are only smaller changes in the results. The addition of operations performed gives a bigger pressure on the locks (table 53). The waiting time for resources are reduced, compared to the former policy combination, except for the hospital orderly where one added resource is not enough to reduce the total waiting time.

Changes in patient flow	Performed operations	Cancellations	Cost pr operation	Average séance time	Emergency patients operated at elective theatre	Average waiting time for emergency patients	Total time difference between planned and actual surgery start	Average changing time
Policy 1 and 2	6 %	-55 %	-7 %	-5 %	-37 %	-19 %	2 %	-3 %
Policy 1, 2 and 4	10 %	-63 %	-9 %	-7 %	-74 %	-52 %	7 %	8 %
Policy 1, 2, 4 and 8	11 %	-65 %	-9 %	-6 %	-71 %	-52 %	2 %	9 %
Policy 1, 2, 4 , 8 and 7	13 %	-71 %	-10 %	-9 %	-75 %	-54 %	17 %	4 %

Table 55: Patient flow results from combining policy 1, 2, 4, 8 and 7

Added times	Waiting time outside lock	Waiting time locking out	Preparation of operation theatre	Extend finalization	Overtime for personnel
Policy 1 and 2	6 %	9 %	34 %	49 %	-18 %
Policy 1, 2 and 4	-10 %	5 %	47 %	37 %	0 %
Policy 1, 2, 4 and 8	-1 %	9 %	47 %	43 %	-4 %
Policy 1, 2, 4 , 8 and 7	4 %	24 %	46 %	32 %	-17 %

Table 56: Added times results from combining policy 1, 2, 4, 8 and 7

Unused capacity	Cost connected to free time	Free time for personnel	Free operation theatre time
Policy 1 and 2	4 %	5 %	7 %
Policy 1, 2 and 4	38 %	35 %	17 %
Policy 1, 2, 4 and 8	36 %	32 %	15 %
Policy 1, 2,4 , 8 and 7	35 %	42 %	16 %

Table 57: Unused capacity results from combining policy 1, 2, 4, 8 and 7

Waiting for personnel	Hospital orderly (locking inn)	Hospital orderly (preparations at SOP)	Anaesthetist (preparations at SOP)	Anaesthetist (finalization)
Policy 1 and 2	28 %	12 %	4 %	9 %
Policy 1, 2 and 4	-1 %	-18 %	29 %	-1 %
Policy 1, 2,4 and 8	13 %	-20 %	81 %	9 %
Policy 1, 2, 4 , 8 and 7	-61 %	55 %	3 %	5 %

Table 58: Waiting time for personnel results from combining policy 1, 2, 4, 8 and 7

The combination of the different policies implies that even though the policy gives good results by itself, other combination can eliminate the need for the policy like adding more beds. The three first combinations and an additional anaesthetist seem to be the best combination of these tested policies giving an increase in production, reduced cancellations and waiting time for emergency patients. A better adjustment of when there is a need for nightshifts and an adjustment of the length of a nightshift might reduce the free time for personnel getting an even better resource utilization.

5.4 Summary and conclusion

There has been performed nine policy test in this thesis connected to seven hypotheses trying to investigate the relationship between the SOP structure and its dynamics over time and identify origins of inefficiencies that SOP is facing as a result of a non-optimal utilization of resources associated with a non-optimal patient flow. The policies have been directed towards bottlenecks and other elements hindering the patient flow and use of available resources. The results show that both exogenous and endogenous elements leads to inefficiencies and that combination of resolving these can also reduce other bottlenecks in the system. A better planning of the surgery program increases resource utilisation and adding shifts gives good results on the waiting time for emergency patients. Not all of the tested policies strengthen the hypothesis but more testing is needed before one can disregard the hypothesis completely.

I will her give a short sum up of the hypothesis:

1. *Delays caused by exogenous factors acting upon the system reduces the patient flow.* The results show that the delays do reduce the flow by delaying performance of activities.

2. *Improving the planning of the surgery program will increase the predictability of the program and, thereby, the patient flow.* The importance in good planning and the importance of a feasible surgery program is to a great extent confirmed though the policy.

3. *Exercising a certain flexibility regarding when dayshifts should end will prevent patient flow obstructions from early daytime de-escalation.* Yes, overtime leads to less de-escalation and increased production but does not improve the patient flow in general.

4. *A good emergency patient flow is hindered by the lack of resources (personnel and operation theatres) at night.* There is an overall improvement in the patient flow by adding an entire shift. Although, the shift is not needed to work at night but can be added as an evening shift.

5. *A non-optimal patient flow is due to lack of personnel causing a bottleneck in the system.* Some personnel groups in the system can cause delays due to unavailability, but they are not extensive enough to cause big obstructions in the flow. The need for more personnel might arise if there is a better patient flow and fewer obstructions from other elements on the flow (as showed in the combination of policies chapter 5.3).

6. *Bottlenecks caused by lack of resources outside SOP constrains the patient flow through SOP.* The hypothesis is strengthen through the policy of added beds at the postoperative divisions.

7. *The lack of free locks constitutes a bottleneck that leads to a sub-optimal patient flow caused by a poor utilisation of resources.* The policy tested did

not give strength to the hypothesis. But, I believe that the locks to some extent contribute to a sub-optimal flow. Other tests are therefore needed to completely diminish the hypothesis.

5.5 Further research

The process of modeling this complex system has been long and complex and lead to a model that needs about 48 hours to complete one simulation run. The policies presented in this thesis gives only a portion of the models potential and further policy testing is therefore advisable. Both to exploit the model to its fullest but also to explore the possibilities of detail modeling by using a System Dynamic approach. I will here represent some of my ideas to further testing and research.

5.5.1 Extended policy testing and model changes

The model does to a little extent consider the patients condition through waiting time and séance time. A deeper study of patient recovery can implicate to what extent a patients waiting time influences the patients condition after a procedure. Together with an expanded planning of a surgery program this can lead to policies as to which patients needs to be prioritized and the consequences this can get for those in line – both elective and acute.

It is said that one can not plan the emergency flow of patients. Through my job – working with hospital issues – I have seen that the emergency inflow to different hospitals have many resemblances. The model can be used to test to what extent it is possible to plan an operation program for emergency procedures and the costs this would lead to.

To be able to imply the further need for operations there is a need for a deeper study of the development of technology. Stomach ulcer was earlier a surgical procedure, today this is treated medical and no operation is needed. The model can in a future perspective give incentives to which sections that will need added resources and if a new organization of the available resources is needed.

Other changes that could be interesting to study are soft variables like stress and to what extent experience to the personnel affects the patient flow and the resource use. There should also be an extended focus on costs, finances and technology connected to operation performance to give a better idea as to what an improved flow will lead to of cost reductions or increases, and together with the future perspective what will this cost the society in the future.

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7 Appendixes

Appendix A: Simulation model equations – in CD

Appendix B: Data used in the simulation model – in CD

Appendix C: Print screens from ORBIT

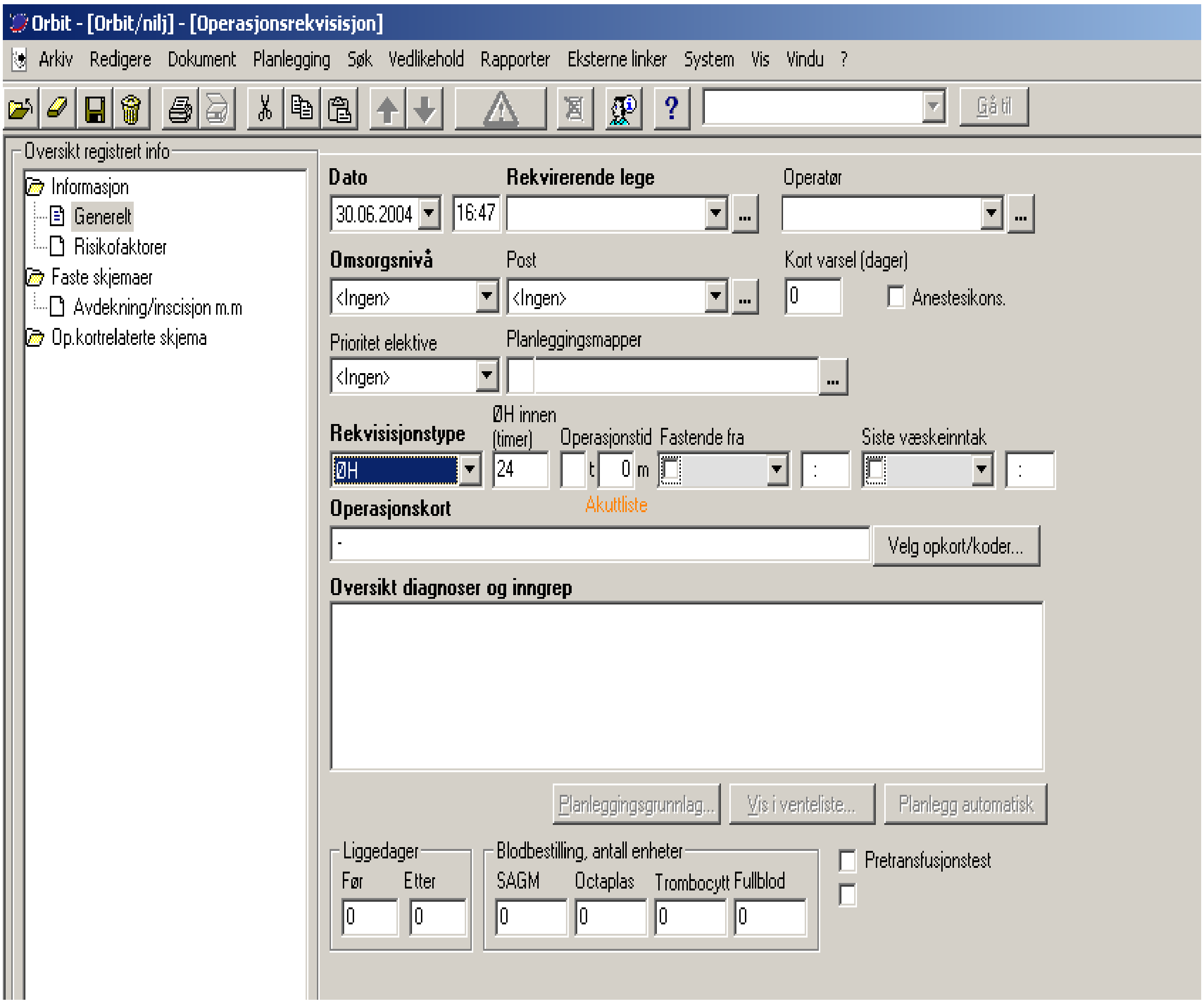
Appendix D: Modeled interface

Appendix E: Group interviews performed in collaboration with Prosess Partner

Appendix F: Summary of gathered information through interviews at Haukeland Universitets sykehus.

Appendix G: ABC-analyses – in CD

7.1 Appendix C: Print screens from ORBIT



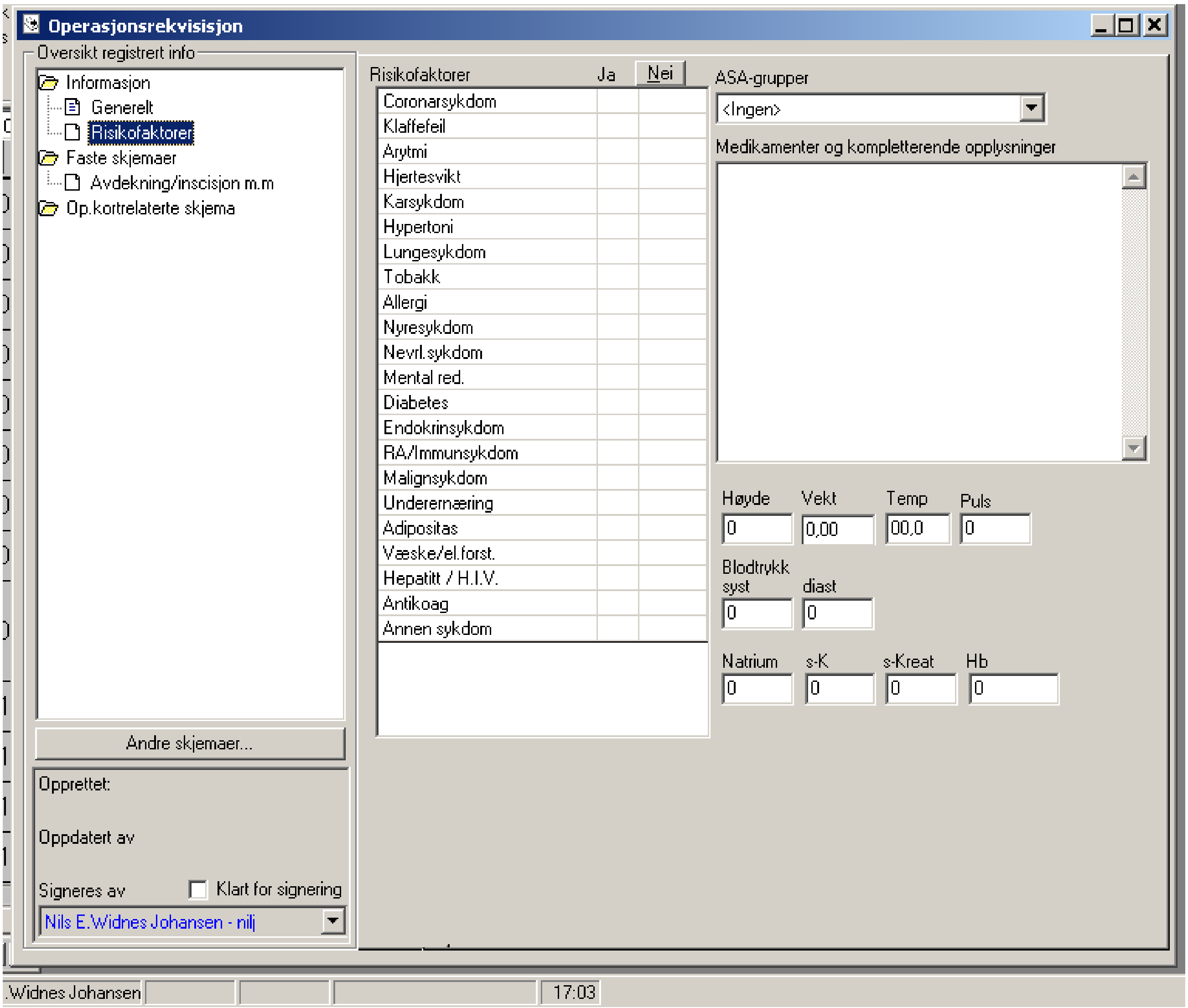
Plukklister:

Omsorgsnivå:
Dagkirurgisk
Inneliggende
Poliklinisk

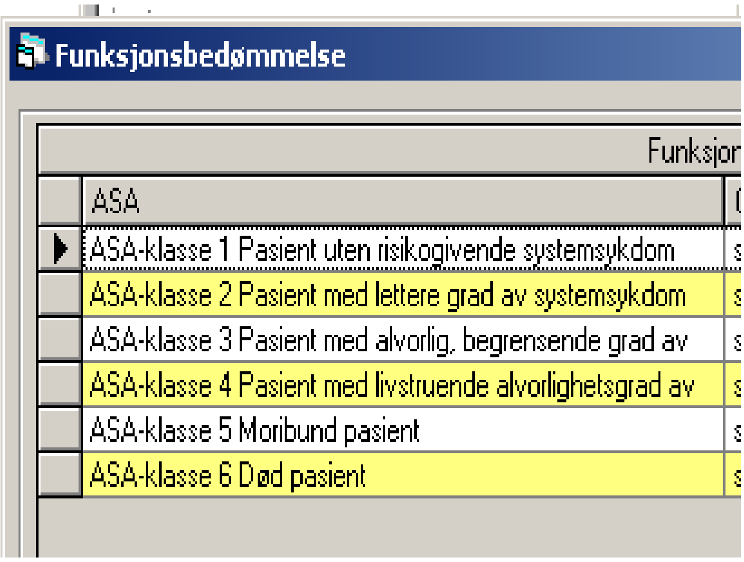
Prioritet elektive:

A innen 24 timer	0
B innen 3 dager	3
C innen 1 uke	7
D innen 2 uker	14
E innen 4 uker	28
F innen 6 uker	42
G innen 3 måneder	90
H innen 6 måneder	180
J Avtalt kontroll	365
Ikke spesifisert	0
I Ikke tidsavhengig	365
Avtalt tidspunkt	365

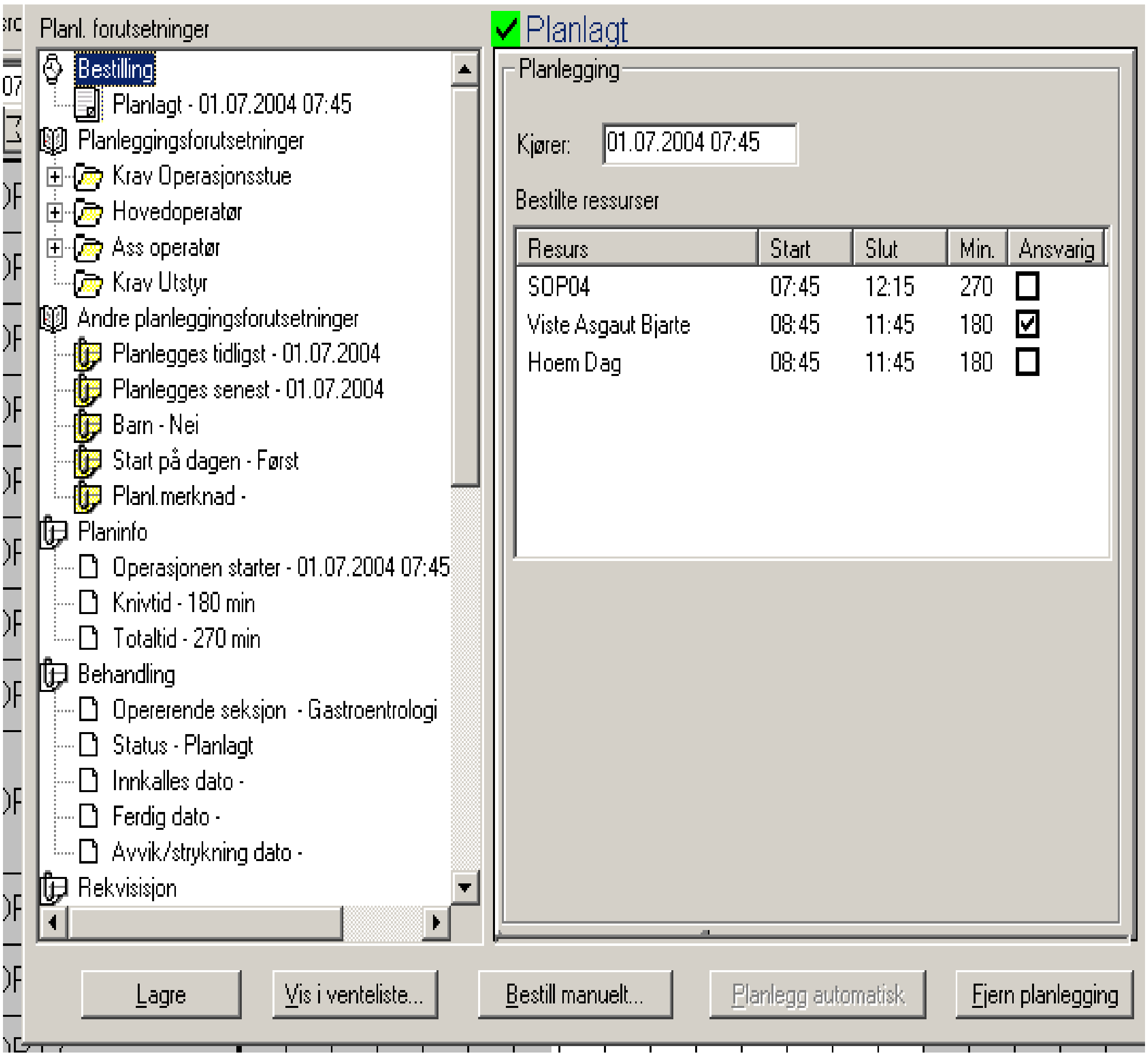
Rekvisisjonstype:
ØH
Elektiv


Operasjonsrekvisisjon
Oversikt registrert info
Informasjon
Generelt
Risikofaktorer
Faste skjemaer
Avdekning/inscisjon m.m
Op.kortrelaterte skjema
Andre skjemaer...
Opprettet:
Oppdatert av
Signeres av
Klart for signering
Nils E.Widnes Johansen - nilj
Risikofaktorer
Ja
Nei
Coronarsykdom
Klaffefeil
Arytmi
Hjertesvikt
Karsykdom
Hypertoni
Lungesykdom
Tobakk
Allergi
Nyresykdom
Nevrl.sykdom
Mental red.
Diabetes
Endokrinsykdom
RA/Immunsykdom
Malignsykdom
Underernæring
Adipositas
Væske/el.forst.
Hepatitt / H.I.V.
Antikoag
Annen sykdom
ASA-grupper
<Ingen>
Medikamenter og kompletterende opplysninger
Høyde
Vekt
Temp
Puls
0
0,00
00,0
0
Blodtrykk syst
diast
0
0
Natrium
s-K
s-Kreat
Hb
0
0
0
0
Widnes Johansen
17:03

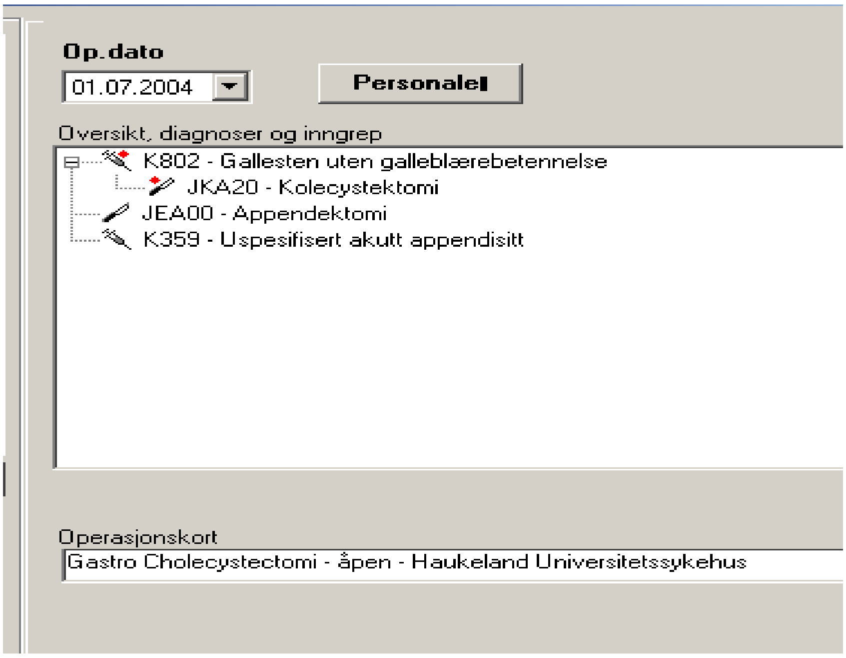
Asagrupper:



Planleggingsgrunnlag (elektive pas)

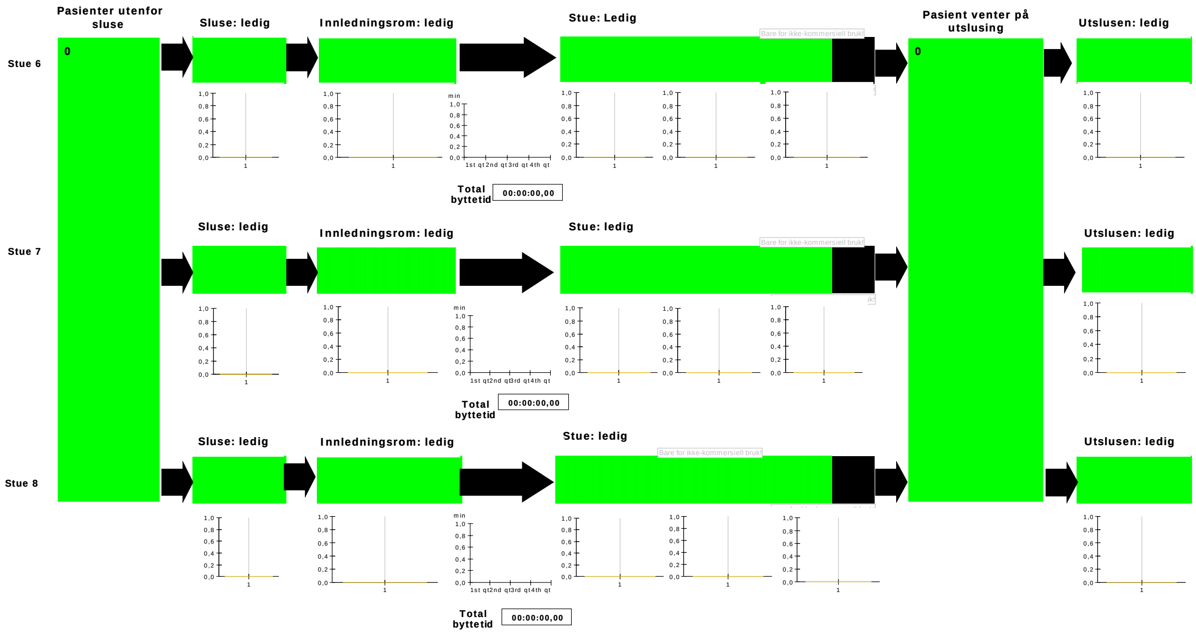


Operasjonsregistrering operatør
(etter utført inngrep)

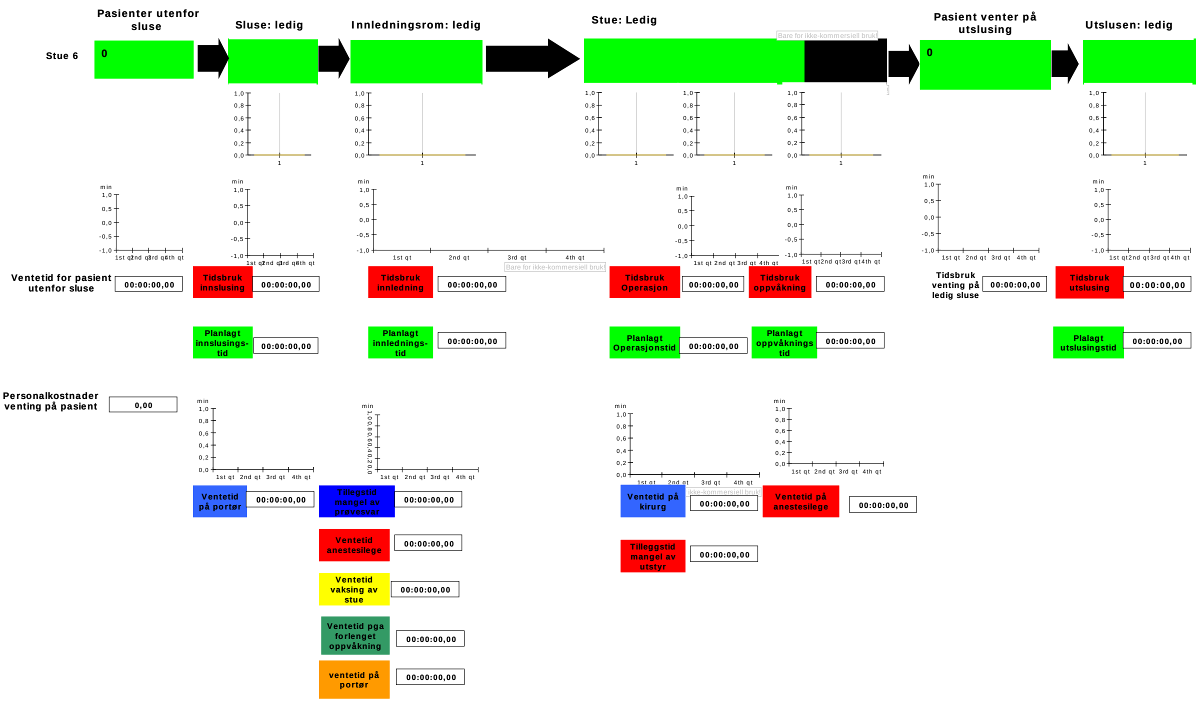


7.2 Appendix D: Modeled interface

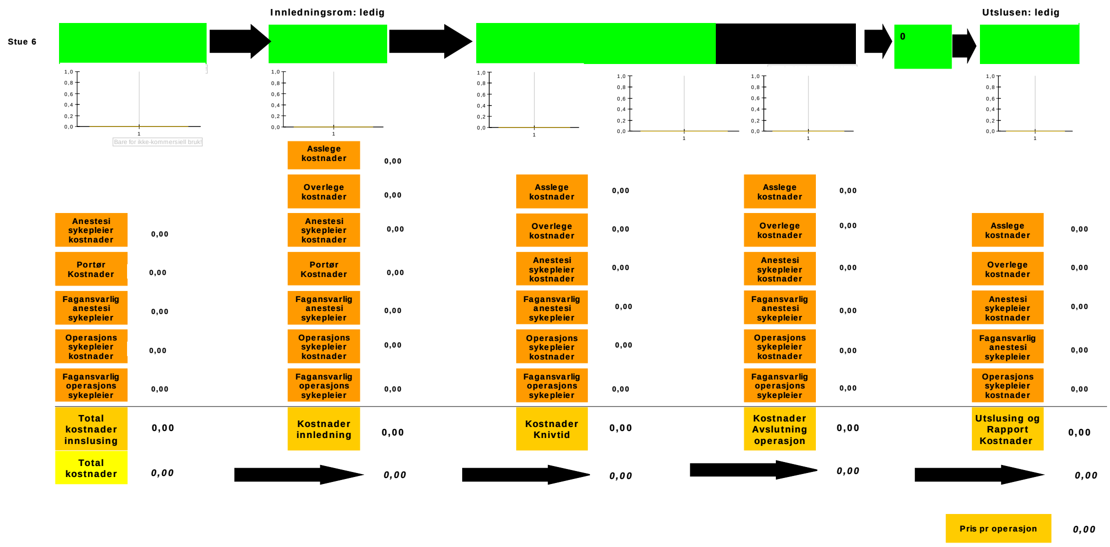
Patient flow



Time use and delay times



Cost accumulation



7.3 Appendix E: Group interviews performed in collaboration with Prosess Partner

KSK i omstilling
gruppeintervju OT

Forventinger: at gruppeintervju er en mulighet for at alle skal bli hørt.

Planlegging/ forberedelse til operasjon
<u>Spørsmål 1</u>
Hvordan fungerer dagens planlegging av operasjonsaktivitet i forhold til de enkelte yrkesgruppers behov for å forbedre egen innsats innenfor:

ØH-aktivitet?
Elektiv virksomhet?

Hvordan har seksjoneringen påvirket dette?

Hva er bra
Øyeblikkelig hjelp

- På grunn av Orbit er planlegging og forberedelse til operasjoner blitt bedre. Med en gang en pasient er blitt meldt kan klargjøringen av pasienten begynne. *(Dette kan kanskje ha innvirkning på preopr tid for pasienten??? At den er blitt mindre?? Sjekk dette i forhold til data fra Pims).*
- På kveld og helg har planleggingen blitt bedre på grunn av bedre forutsigbarhet som er et resultat av seksjoneringen.
- Pax og Orbit blir nevnt som gode verktøy når det gjelder planlegging av operasjoner og tilgjengelige data fåes raskt.
- Det at OT har en egen øh -stue har bedret kapasiteten angående ØH i tillegg til at de slipper å spørre andre seksjoner om lån av stue fordi de har kontroll over ØH -stuen selv.
- Seksjoneringen har ført til en tryggere og mer kontrollert arbeidsdag (*assistenter og portører*).
- For operatører har seksjoneringen ført til bedre forutsigbarhet og sammen med teknologi har dette bedret planlegging av operasjoner.
- Anestesi føler at bruk av Orbit har bedret planleggingsprosessen.

Elektiv

- På kirurg (bruker) siden sees seksjonering på som positivt sammen med Orbit har det ført til at de bedre kan styre selv planlegging og gjennomføring av operasjoner. Men det blir pekt på at det er for få anestesileger.
- 6 anestesisykepleiere gir en god flyt og alle få tatt lunsj,
- Det er blitt mindre strykning fordi en har bedre kontroll over tilgjengelige personalressurser.

Hva kan bli bedre
Øyeblikkelig hjelp

- Den daglige driften går ut over ØH planleggingen. Dette har med kapasiteten til operasjonssykepleierne at de samtidig med å planlegge ØH- virksomhet må holde utstyrsparken. Operasjonssykepleiernes daglige gjøremål som at de skal planlegge og forberede seg til operasjoner og samtidig holde på med pakking av utstyr osv. gjør at det blir mindre tid til å forberede seg til ØH operasjoner. Dette litt fordi at elektive er mer planlagt i forveien mens ØH operasjoner går hele tiden og er mer uforutsigbare.
- Anestesisykepleierne har en calling funksjon (*om kveld og i helg tror jeg, sjekk her med tidligere intervju*) noe som gjør at de har dobbelt arbeid (*må kunne være tilgjengelig for flere stuer*).
- Endringer i prioritering fører til tap av operasjonstid, en føler at det hindrer en god flyt. For blant annet anestesisykepleierne kan endringer av prioritering føre til tap av operasjonstid. Dette fordi de har forberedt ferdig til en pasient, men får så beskjed om at prioriteringen av pasientene er endret og må da starte med en ny forberedelse. Dette fører til tap av operasjonstid. *(Dette vil også si at kostnadene (tiden) som er gått med til den første forberedelsen ikke kan knyttes til pasienten og er derfor et tap eventuelt plunder og heft kostnad.)* Endringer av prioritet fører litt til frustrasjon fordi det er dårlig utnyttelse av tid.
- Det er en skjev fordeling angående personalressurser, der noen sliter mer enn andre. Det er til tider en veldig dårlig balanse angående personale når det gjelder planlegging av turnus. Det gir en skjev fordeling av operasjonssykepleiere og anestesisykepleiere som for eksempel at det er 7 anestesisykepleiere og kun 5 operasjonssykepleiere. Dette skaper et større arbeidspress på den gruppen som er i undertall i forhold til normen.
- Erfaring har noe å si for pasientflyten. Det å sette f.eks en uerfaren anestesilege på vakt i helgen kan føre til stor forsinkelser i flyten. Det vil si at en uerfaren på ett eller flere steg i prosessen kan forsinke den totale prosessen. (*Det var her mest snakk om helg og kveld da det er da de er færre på vakt*).
- Kommunikasjonen med post kan bli bedre. Pasienten ligger på post og bedre kommunikasjon mellom post og SOP kan gjøre at de på post starter forberedelsene av pasienten der raskere. Dette gjelder spesielt angående ØH pasienter. Et forslag på løsning av dette er at de på post får tilgang til Orbit.
- Klarere retningslinjer/eller at de retningslinjene som eksisterer blir fulgt bedre angående prioritering av pasienter.
- Operasjonssykepleiere føler seg utnyttet angående overtid. De føler at det spekuleres i overtid. Som oftest er de villig til å gjennomføre operasjoner på grunn av køer.
- Det kan bli en bedring av utnyttelsen av tid generelt, dette gjelder spesielt vakt (kveld/natt/helg).
- Det kan forekomme at et team står klart, men at det mangler en operatør. (*en grunn til dette er at formidling av hvem som skal utføre operasjonen kan være dårlig*).
- Endringer av programmet meldes for seint til SOP. Dette kan gjøre at en har forberedt en operasjon, men at en så får beskjed om at det er endringer i programmet og en må starte på en ny forberedelse.

- Planlegging i helg går ut over arbeidstiden. Her ble det sagt at all tiden som personalet har tilgjengelig blir brukt opp med en gang. (*det kan tyde på at de syntes at utnyttelsen av den tiden som helgevakt team har tilgjengelig blir for dårlig utnyttet*).
- Seksjonen er veldig følsom overfor sykdom. Det kan føre til stryk eller at andre må strekke seg langt for å få gjennomført programmet.
- Dager med kun 5 anestesisykepleiere går pasientflyten saktere, det kan også gjøre at de ansvarlige anestesisykepleierne ikke spiser lunsj for å opprettholde flyten.
- Det er egne pasienttyper som skal opereres på beredskapstid, men overtid fredag-søndag sliter på personalet på grunn av at de har arbeidsoppgaver utenom selve knivtiden (den tiden da operatør er tilstedet). (*Det vil si at dersom de jobber overtid på grunn av knivtid kan de ikke gå etter endt operasjon. De må jobbe utover knivtiden på grunn av at de har oppgaver som opprydding osv.*) Dette kan få konsekvenser for vakter på mandagen og kan føre til endringer i vakt.
- Det kom fram at uerfarne personale på vakt i helger/kveld, og da ble det mest pekt på operatører på vakt i helgene, fører til at det oppstår mye forsinkelser. Det tar også lengre tid før for eksempel operatøren kan få hjelp av en mer erfaren. Dette sliter på de andre personalgruppene som er med i teamet *(spesielt operasjonssykepleierne ble det sagt*) fordi det fører til lengre operasjonstider, overtid og at flyten går tregere.

Kommunikasjon og samarbeid
<u>Spørsmål 1 Kirurgi –SOP (Orbit, melding av pasient)</u>
Får anestesilege, anestesi- og operasjonssykepleiere tidsnok, korrekt og fullstendig nok informasjon til en optimal planlegging og gjennomføring av sine oppgaver?

Hvordan har seksjoneringen påvirket dette?

<u>Spørsmål 2 Anestesilege/anestesisykepleiere/operasjonssykepleiere</u>
Hvordan fungerer dagens kommunikasjon og samarbeid omkring alle oppgavene som skal utføres før kirurgien skal begynne?

Hvordan har seksjoneringen påvirket dette?

Hvordan har organiseringen av operasjons- og anestesisykepleiere under èn, felles leder påvirket samarbeidet mellom og koordineringen av disse to gruppene?

<u>Spørsmål 3 kommunikasjon SOP- sengepost</u>
Er personalet i SOP og ved sengepost tilstrekkelig tilgjenglige for hverandre for å avklare dagens mange spørsmål?

Hvordan har seksjoneringen påvirket dette?

Hva er bra
Spørsmål 1

- Orbit har bedret samarbeidet og det samme har ”docline”.
- Bedring etter seksjoneringen.

Spørsmål 2

- Kortere kommunikasjonslinjer, bedre med en sjef/leder (seksjonsleder)
- Orbit har ført til at det er lettere å få informasjon om pasient. (*formidlinger som operatør har om pasient kommer lettere fram*)
- Bedre kommunikasjon på grunn av at de kjenner ansiktene og hverandre bedre. Dette gjelder de som jobber på SOP, men også forholdet personalet på SOP og kirurg.
- Bedre sosialt både på SOP generelt (*innenfor seksjonen*) og en bedre stemning på stuene (*men det ble påpekt at dager med mye slit fører til at folk lettere blir irritert*).

Hva kan bli bedre

- Etterlysning av å ha Orbit på post. (*Det ble antydet at dette kan bedre informasjonsformidlingen bedre mellom SOP og post*).
- Seksjoneringen har ført til en bedring av samarbeid, men på grunn av at det har forsvunnet en del klarerte oppgave inndelinger på stuene sliter dette mer på noen av personalgruppene. En bedre inndeling/ansvarsområde blir ettersøkt. Seksjoneringen har ført til at tilgjengelig ressurs skal gjøre utføre de nødvendige oppgavene. Før seksjoneringen var ulike oppgaver mer knyttet til forskjellige personalgrupper. Dagens løsning har gjort at noen personalgrupper føler de må gjøre oppgaver som de ikke har tid til og som før ikke var oppgaver de hadde ansvar for.
- Savner et enda bedre felleskap.
- SOP er enda litt dominert av gamle kulturer.
- Mer respekt for andre sine gjøremål (*her ble det påpekt mellom anestesisykepleier og operasjonssykepleier*). Det forekommer at når anestesisykepleieren er ferdig med sin arbeidsoppgave kaller de på operatøren og tar ikke hensyn til at operasjonssykepleier ikke er ferdig med sine oppg.
- Ikke alle pasientene blir lagt inn i Orbit før de kommer til SOP, dette gjelder spesielt akutte ØH pasienter.
- Mangelfull utfylling av Orbit
- Mangelfulle journaler på anestesi- siden
- Lege /sykepleier på post tar for seint kontakt ved calling. (*En mulig løsning er å skape en mer nærhet mellom Post og de på SOP slike at det blir en økt forståelse angående arbeidsdag og arbeidsoppgaver).*

Kapasitet

<u>Spørsmål 3 oppstart om morgenen og tid mellom operasjoner</u>

Hvilke faktorer utover god kommunikasjon og god planlegging er kritiske for

a) Tidligst mulig oppstart om morgenen og
b) Rask og samtidig faglig tilfredsstillende oppstart av ny operasjon på samme stue?

Eventuelle personalgrupper som har for mange baller i luften og som derfor stadig må ventes på?

Hvordan har seksjoneringen påvirket dette?

<u>Spørsmål 4 Kapasitet andre personellgrupper</u>

Hvordan påvirker kapasiteten innenfor merkantilfunksjoner, renhold og portørtjenester pasientflyten i SOP?

Hvordan har seksjoneringen påvirket dette?

Spørsmål 5 Fysiske forhold i SOP eller utstyrsmangel som påvirker pasientflyten?

Hva er bra
Beredskap

- Det er alltid noen som kan OT.
- Det er mindre nattarbeid, men det kan være vakter som varer opp til 14 timer noe som er maksimalt av hva som er lovlig. Nattarbeid fører også til at en kommer seinere i gang på en stue dagen etter på grunn av at de skal gå 10 timer fri mellom slike vakter.
- Kirurgene har fått en faglig forbedring.
- Bedre opprettholdt beredskap har ført til at det opereres flere.

Hva kan bli bedre

- Kirurg (bruker) syntes at det er for få anestesileger, 1 anestesilege for lite.
- Operasjonssykepleierne er for få, de er i dag syv, men bør være 8.
- Dårlig kapasitet for anestesisykepleierne når de er 5. Det blir mange pasienter som samtidig trenger anestesisykepleiere. Det gjør at flyten går tregere og at flere operasjoner må strykes.
- Kirurger trenger 1 til for å få utnytte dagkirurgi optimalt sammen med SOP.
- Fagansvarligsykepleier må i større grad få ta seg av utstyrsmengden og de trenger da en operasjonssykepleier til.
- 1 operasjonssykepleier for lite i vaktskiftet. Her kom det fram at personalet ønsker helst dagvakt eller seinvakt, mellomvakten er lite populær.
- Dersom de skal opererer mindre elektivt vil det vanskeliggjøre kontrollen over virksomheten.
- de er sårbart i overgangen mellom vakter
- økt vaktbelastning på alle
- Bedre punktlighet når det gjelder oppstart av operasjoner om morningen.
- Byttetid: tar ikke hensyn til at assistentene må vaske.
- Portører i manko om morningen (*ikke seksjonert*).
- Det blir påstått at OT er underbemannet av operasjonssykepleiere og anestesisykepleiere om kveld og i helg. Mangel på operasjonssykepleiere kan føre til mer hektiske arbeidsdager for andre personalgrupper som assistenter. *(De får mindre hjelp angående klargjøring av stue og mer arbeid med reingjøring/klargjøring av utstyr).*

Beredskap

- Operasjonssykepleierne må gå lengre vakter.

Annet
(*Ot bakvakt fra 9 – 15 over dette har bakvakten hjemmekalling og kan bli tilkaldt*)

Kapasiteten er utnytten på OT.

Det ble påpekt at det må bli en bedre balanse mellom kirurger og personalet på SOP. Kirurger vil operere mer, men personalet på SOP utnytter i dag kapasiteten deres 100%.

(Personalet på SOP kan jobbe overtid uten at det vil påvirke neste dags vakt dvs. at de må møte dagen etter kl 8.00 (operasjonssykepleiere). Men for mye overtid til føre til at de må hvile i 10 timer og det vil gå ut over neste dags program og føre til at elektive operasjoner blir strøket. Operasjonssykepleierne føler at det spekuleres i denne tiden angående hvor mye overtid de kan jobbe uten at det går ut over neste dags vakt).

KSK i omstilling Hode/Hals seksjon

Forventinger: et forum for utveksling av ideer. At noe skal skje, at det skal komme resultater ut av deltagelsen.

Planlegging/ forberedelse til operasjon
<u>Spørsmål 1</u>
Hvordan fungerer dagens planlegging av operasjonsaktivitet i forhold til de enkelte yrkesgruppers behov for å forbedre egen innsats innenfor:

a) ØH-aktivitet?
b) Elektiv virksomhet?

Hvordan har seksjoneringen påvirket dette?

Hva er bra
- Positive til seksjoneringen.
- Mindre strykninger
- Godt samarbeid
- Fått det bedre som team.
- Blir fortere kjent med det som skal gjøres.
- Mer effektive, de har mer kunnskap.
- Bedre samarbeid innenfor seksjonen.

Hva kan gjøres bedre
Øyeblikkelig hjelp
- Mangler øh- team.
- På kveld er det for lite øh- kapasitet når det gjelder operasjonssykepleiere. Mandag til onsdag har de langvarige operasjoner der det er stor usikkerhet på hvor lenge operasjonen varer. Dersom det da er kun to operasjonssykepleiere er det for lite for å klare øh godt, med 3 klarer de det bedre.
- I tilfeller med 0-prioritet pasienter blir det vanskelig for personalet.
- Bruker: det er tilfeller der 0-prioriteten blir missbrukt dvs. at pasienter som ikke er akutte får 0-prioirteten kun for at pasienten skal kommer fortere gjennom systemet. (*Personalet på SOP mener at dette har kommet seg*)
- Dårlig planlegging av øh. pasienter opp i mot kapasiteten som er tilgjengelig på SOP. Det forekommer at ved ledig kapasitet på SOP er ikke pasienten

klargjort i det de på SOP kaller ned pasienten. Dette gjelder mest i overtagelse/vaktskifte. Andre mener her at det er stort sett klarerte pasienter som blir meld.
- Øh. pasienter kommer inn for seint, uforutsigbar levering.
- For treg levering av elektive pasienter
- Det går for tregt i slusene.
- Øh pasienter mangelfull informasjon fra seksjonsleder angående hvor pasienten skal og informasjon om hvem som skal gjennomføre/delta på operasjonen.
- Mangelfull utfylling av operasjonsbeskrivelser fra kirurg
- Ikke bra nok bemanning av øh kveld/helg/natt.
- Ved bruk av øh personell har en ingen som kan ta i mot øh pasienter, her må en enten ikke bruke øh personellet for å ha noen til overs eller bruke alle. (*Tror det gjelder bruk av personell innen elektiv virksomhet*).
- Ikke så god opplæring av operasjonssykepleiere på grunn av programmoppsettet.
- Forsinkelser om morningen ved innslusing

Elektiv
- Urealistiske operasjonsprogram i forhold til tid.
- Innslusing om morningen skaper køer når alle skal sluse inn sine pasienter kl ti på åtte.
- Lang ventetid på anestesilege. Før kunne anestesisykepleier starte innledning av pasienter som var ”friske”, men det får det ikke lov til i dag. Mister tid ved å vente på anestesileger. (*har dette gjort at det er blitt mer å gjøre for anestesilegen og at ventetiden på legen er blitt større?*).
- Ofte oppstår det mangler ved pasienten, at prøver mangler eller at pasienten ikke har strømpe på. Dette kan komme på grunn av den dårlige kommunikasjonen mellom SOP og avdelingen om hva som skal være klart ved pasient i det pasienten kommer ned til SOP som nedsending av prøvesvar osv.
- Mangler ved pasienten sinker oppstart av innledning av pasient ved at anestesilegen ikke vil begynne med pasienten før alt med pasienten er klart dvs. alle papirene er i orden.
- Dårlig kommunikasjon mellom anestesileger om pasienten. En anestesilege kan utføre previsitten mens det er en annen som skal innlede pasienten på SOP. Anestesilegen på SOP bruker da mye tid på å sette seg inn i pasientens papirer noe som er frustrerende for personalet på SOP fordi det forsinker operasjonsoppstart. Det skaper også problemer for anestesisykepleiere som kan ha forberedt medikamenter ut i fra operasjonsrekvisisjonen, men at anestesilegen ved ankomst vil ha andre medikamenter noe som gjør at anestesisykepleieren må begynne på nytt.
- Pasienter som ikke er klarerte skal hentes ned. I de tilfellene pasienten skal gjennom en stor operasjon og ikke er klargjort når det er klart for nedkalling av pasienten kan det føre til at operasjonen må strykes. Ved store operasjoner gjør dette at personalet ikke har operativvirksomhet, og det fører til tap av kostnader.
- Det er tilfeller det ikke er klart hvem som skal være operatør.

- Opplæring av personalet fører til at økt tidsbruk. Dette er litt frustrerende for personalet på SOP at de ikke får vite om operatøren har god kjennskap til inngrepet eller er under opplæring. Dette fordi de med god kjennskap kan gjennomføre operasjonen på halvparten av tiden i forhold til en under opplæring.
- Det ble etterlyst bedre merking av pasienter ved kompliserte inngrep/eller ved pasienter der det er vanskelig å finne for eksempel svulster osv. Dette fordi det ofte blir utført en oppdekning av pasienten, men når operatør kommer er han/hun ikke fornøyd med oppdekning og den må da gjøres på nytt, det fører til tap av tid. Alternative er at operatør er med på oppdekningen av pasienter der det er vanskeligheter ved pasienten eller et komplisert inngrep.
- Det går tid vekk ved at de ulike anestesilegene skal fordele pasienter/ansvarsfordeling av pasienter, det forsinker operasjonsoppstart.
- Det er gjort avtale om at operatør skal komme halv ni på stuen, men det er ofte forsinkelser på SOP (*blant annet på grunn av anestesilege*) som gjør at det blir brukt mer tid på innledning. Dette skaper en vanskelig situasjon for operatørene som da kan begynne på andre oppgaver som de ikke bare kan løpe fra i det de blir kalt ned på SOP.
- Mangel av papir fører til forsinkelser, dårlig planlegging av prøver osv.
- Anestesilegene går på previsitt om ettermiddagen dette gjør at det blir mangel av anestesileger på SOP som skaper forsinkelser.
- Anestesileger som gjør previsitt er ikke de somme som innleder pasienten. (et men her er at de aldri har hatt så mange anestesileger som de har nå. Dette kan tyde på en dårlig utnyttelse eller allokering av legene.)
- Ved innslusing må de som sluser inn ha forståelse for at dersom de bruker mye tid så forplanter forsinkelser seg for de andre.
- Dårlige operasjonsbeskrivelser, utfyllingen blir ikke vektlagt dette fører til tap av tid. Operatør bør selv fylle ut tidsbruken som operasjonen skal ta.
- Personalet må i noen tilfeller lette etter fellesutstyr for SOP.
- For lang tid mellom operasjoner/ for mye dø-tid. Ofte stor bytte tid mellom operasjoner. Det kan gå timer mellom en operasjon til den neste. Mye operasjonstid går ikke med til å operere.
- Nedring av pasient skjer for seint (*se i sammenheng med for lang tid mellom operasjoner*)
- Lang avslutning/oppvåknings tid av pasienten. Hele teamet er da låst til stuen (*utenom operatør*), resten av teamet får ikke forlate stuen før pasienten er vekket opp. Det som kom fram her er at på dag kirurgien våkner pasienten i løpet av 15 min mens på sop tar det mye lengre tid. Dette skaper forsinkelser ved f.eks at anestesisykepleieren ikke kan sluse inn nye pasienter eller at operasjonssykepleierne kan begynne innleding av ny pasient.(*må være 2 operasjonssykepleiere ved oppvekking i tilfelle noe skjer*)
- Fagsykepleier går i drift.

<u>Orbit (tror disse på pekningene er mer generelle både for Øh og for elektive)</u>

- Tilleggsopplysningene er for lite i Orbit
- Dårlig rapport fra Orbit
- Rubrikk "informasjon til personalet" er lite brukt.
- En operatør fyller ut Orbit mens det er en annen som opererer og han/hun vil kanskje ha et annet oppdekke enn det som er beskrevet i Orbit.

- Tidene på Orbit kortene må kunne lettere endres.
- Operasjonsskjema er dårlige i Orbit.
- Dårlig utfylling av Orbit.

Annet

- Forslag om å fortsette med å seksjoner seksjonen, ved å delen den ytterligere opp f. eks i to seksjoner med en egen for nevrokirurgi. I sykehus med egen nevro -anestesilege og operasjonssykepleiere går disse operasjonene fortere.

- Ved andre sykehus har det gjennom økt seksjonering skap en mer arbeidstilhørighet blant de ansatte. Der det er slik at en får gå hjem etter gjennomført program har det vist seg at det er sjelden at operasjonsprogrammet ikke blir gjennomført.

- Det ble sagt at en økning av personaltilfredshet vil føre til en enda større kvalitet i arbeidet.
- Det er koordinatene har stueansvar

Kommunikasjon og samarbeid

Spørsmål 1 Kirurgi –SOP (Orbit, melding av pasient)

Får anestesilege, anestesi- og operasjonssykepleiere tidsnok, korrekt og fullstendig nok informasjon til en optimal planlegging og gjennomføring av sine oppgaver?

Hvordan har seksjoneringen påvirket dette?

Spørsmål 2 Anestesilege/anestesisykepleiere/operasjonssykepleiere

Hvordan fungerer dagens kommunikasjon og samarbeid omkring alle oppgavene som skal utføres før kirurgien skal begynne?

Hvordan har seksjoneringen påvirket dette?

Hvordan har organiseringen av operasjons- og anestesisykepleiere under èn, felles leder påvirket samarbeidet mellom og koordineringen av disse to gruppene?

Spørsmål 3 kommunikasjon SOP- sengepost

Er personalet i SOP og ved sengepost tilstrekkelig tilgjenglige for hverandre for å avklare dagens mange spørsmål?

Hvordan har seksjoneringen påvirket dette?

Hva er bra

- Det er godt samarbeid mellom personalet på seksjonen
- God samarbeid mellom operasjonssykepleier og anestesisykepleier
- Vil ikke gå vekk i fra seksjoneringen, det er en god stemning på jobb/på stuene.

Hva kan bli bedre

- Ting kan gå tregt.

- Dårlig kommunikasjon ved endring av operasjonsprogram.
- Overtid avtales seint (*dette på tross at en tidelig kan si om operasjonsprogrammet vil føre til overtid*)
- Dårlig avklaring mellom anestesisykepleier og anestesilege, det er ingen møtevirksomhet mellom disse angående pasienter.
- Lite kontroll over utstyr.
- ”Murene” i Sop er blitt så høye at en ikke ser hvordan andre seksjoner løser de ulike problemene.
- Ikke noe forum der problemer som angår hele SOP kan taes opp
- Litt skurring mellom post og SOP. En må opplyse personalet mer om hva post og Sop trenger.
- Anestesisykepleierne vil ha en mer generell kompetanse.
- En ytterligere seksjonering vil skape problemer angående beredskap av ØH på kveld og helg.
- Det må være en rett sammensetning av personale
- Rette personer må gjøre de rette tingene.

<u>En leder</u>

- Det er ingen forbedreing
- Det er dårlig og uoversiktlig *(tror det var i forbindelse med turnus*) og leder er ofte vanskelig å få tak i.
- Det er ingen fellesmøter med leder og personale.
- Det er ingen personalet daglig kan henvende seg til angående problemer.
- Ingen felles ansvarshavende for utstyr osv. på SOP.
- Ingen gevinst i forhold til kommunikasjon.
- Bedre kommunikasjon om overtagelser av oppgaver dersom det er nødvendig.
- Det er en leder som har 50 medarbeidere, der leder sitter aleine med ansvar over turnus, budsjett, medarbeidersamtaler osv. Det må bli en bedre delegering av arbeidsoppgaver.
- Ved at leder er en anestesisykepleier har dette ført til mer ansvar for fagansvarlig operasjonssykepleier.

<u>Post- Sop</u>

- Fungerer stort sett bra
- Anestesi får ofte mangelfull informasjon
- Ønske om at post leverer pasienten mer presist når det gjelder klokkeslett.

Annet

- Hode/hals har nesten ikke operasjoner på natt og kunne da ha hatt hjemmevakt istedenfor å ha beredskap på SOP. Den beredskapen som Hode/hals har på kveld/helg er med på å dekke opp på hele SOP. Ved å ha hjemmevakt vil kostnadene for hode/hals for beredskap gå ned. Dersom det kommer en akutt pasient kan teamet være på plass innen en halv time. Slik det er i dag har de mange nattevakter både for erfarne og uerfarne noe som sliter på personalet. Det kunne på kveld vært en bedre fordeling av beredskap mellom hode/hals og thorax. I helgen er det vanskelig på grunn av etterhengene fra uken.

- Det kom også fram at lite blir gjort for å holde på personale (lite kurs/videre utvikling/utdanning), også når det gjelder å holde på den kompetanse og erfaring som personalet har.

KSK i omstilling
Kirurgisk seksjon

Planlegging/ forberedelse til operasjon
Spørsmål 1
Hvordan fungerer dagens planlegging av operasjonsaktivitet i forhold til de enkelte yrkesgruppers behov for å forbedre egen innsats innenfor:

c) ØH-aktivitet?
d) Elektiv virksomhet?

Hvordan har seksjoneringen påvirket dette?

Hva er bra
- Ingen endringer angående forbedringer etter seksjoneringen.

Hva kan bli bedre
Elektiv virksomhet
- På anestesi- siden ble det gitt uttrykk for at det er mangelfulle beskrivelser i Orbit.
- Det er stengsler vedrørende utnyttelse av kapasitet på den elektive siden.

ØH
- Manglende kommunikasjon når det er flere ØH pasienter som er likt prioritert, noe som fører til at operasjonssykepleier må videre føre informasjon fordi kirurgene ikke snakker sammen. Dersom to ØH pasienter har i utgangspunktet fått lik prioritering og skal taes samtidig er det dårlig kommunikasjon mellom kirurgene. Det er operasjonssykepleier som må videreformidle informasjon og be kirurgene om å snakke sammen om hvilken pasient som skal taes først. Manglende melding av 0- prioriterte ØH pasienter, pasienten kommer til SOP uten at kirurg har meldt til operasjonssykepleier. (*Det kan ha sammenheng med at de ikke blir registrert i Orbit og at det kan være en mulig løsning her dersom det er mulig*).
- Uklare kommunikasjonslinjer/kommandolinjer etter seksjoneringen som påvirker planlegging av operasjoner. Et eksempel her er at den som har calling 2300 på kirurgiske traumer på vakttid *(avdelingsleder som i dag er anestesisykepleier og som har ansvar for alle på Sop i 0- prioritet ØH situasjoner*) er på Hode/hals seksjonen. De på kirurgisk mener at den som har denne callingen bør være på kirurgisk.
- Det ble også gitt uttrykk for at 2233 som er anestesisykepleier ansvarlig og 2545 bør også ligge på kirurgisk. (*Litt fordi de føler at når traumepasienter som skal på kirurgisk kommer inn og callingen går til Holde/hals så blir ikke disse pasientene sett på som ”like viktige” i den forstand at pasientene ikke er hode/hals pasienter*). Anestesisykepleier og operasjonssykepleier får

mangelfull informasjon om pasienten fordi informasjonen må gå en omvei og ikke rett til den seksjonen som pasienten skal på.
- Manglende informasjon registrert i Orbit.(*denne gjelder nok både ØH og elektive*).

Kommunikasjon og samarbeid

Spørsmål 1 Kirurgi –SOP (Orbit, melding av pasient)

Får anestesilege, anestesi- og operasjonssykepleiere tidsnok, korrekt og fullstendig nok informasjon til en optimal planlegging og gjennomføring av sine oppgaver?

Hvordan har seksjoneringen påvirket dette?

Spørsmål 2 Anestesilege/anestesisykepleiere/operasjonssykepleiere

Hvordan fungerer dagens kommunikasjon og samarbeid omkring alle oppgavene som skal utføres før kirurgien skal begynne?

Hvordan har seksjoneringen påvirket dette?

Hvordan har organiseringen av operasjons- og anestesisykepleiere under èn, felles leder påvirket samarbeidet mellom og koordineringen av disse to gruppene?

Spørsmål 3 kommunikasjon SOP- sengepost

Er personalet i SOP og ved sengepost tilstrekkelig tilgjenglige for hverandre for å avklare dagens mange spørsmål?

Hvordan har seksjoneringen påvirket dette?

Hva er bra

Spørsmål 2
- Tettere kommunikasjon mellom personalet på SOP, de er mer samkjørt og kjenner hverandre bedre. (*Vet hvem som gjør hva angående oppgaver og hvem som ikke er så nøye på ulike oppgaver slik at de lettere kan sjekke at ulikt arbeid er blitt gjennomført*).

Hva kan bli bedre

Spørsmål 1:
- Operasjonskortene må gjøres bedre. I dag må de ringe mye for å sjekke hva som skal gjøres på grunn av ufullstendig utfylling og dårlige operasjonskort, dette gjør at forsinkelser blir større.

En felles leder
- Tar ikke vare på faget. Har liten forståelse/ kjennskap til andre *(i dette tilfellet operasjonssykepleiere da seksjonsleder er anestesisykepleier*) sine arbeidsoppgaver. Det at faget ikke blir ivaretatt er veldig uheldig faglig.
- Det er i dag fire seksjonsledere og de syntes at kommunikasjonen angående vaktordninger er dårlig.
- Det er ønske om at det er en fast (eventuelt en i reserve) som har oversikt over elektivvirksomhet og planlegging av utstyrsbruk over flere dager framover. I dag er dette veldig varierende, spesielt dersom den som pleier å ta seg av disse arbeidsoppgavene er på ferie eller vekke fra jobb.
- Felles leder er uheldig faglig sett i hvert fall slik situasjonen er i dag når fagansvarligoperasjonssykepleier er i full drift (*klinisk arbeid*) og ikke får tid

til å ivareta faget. Den faggruppen som ikke har leder fra sin gruppe lider fordi de har ingen faglig leder.

Spørsmål 2:

- Anestesilege, 2527 calling for vakttid får ikke melding om at pasienten er registrert i Orbit, dette gjelder ØH pasienter.
- Manglende koordinering innenfor faget. Fagansvarligsykepleier har ikke fått stillingsinstrukser og brukes pr i dag i drift og ikke til fag.
- Nye uerfarne anestesileger gjør at mye tid går med til venting for personalet på SOP. Grunnen til dette et at når de ikke klarer å utføre sine arbeidsoppgaver prøver de lenge før de gir opp og tilkaller en mer erfaren lege. Denne ventetiden blir oppfattet som frustrerende fordi det hindrer flyten og fører til at mye tid går vekk. (*Det er her et ønske om at de uerfarne må ha en mer erfaren med seg eller i hver fall tilkalle den erfarne tidligere*).

Kapasitet

<u>Spørsmål 3 oppstart om morgenen og tid mellom operasjoner</u>

Hvilke faktorer utover god kommunikasjon og god planlegging er kritiske for

c) Tidligst mulig oppstart om morgenen og
d) Rask og samtidig faglig tilfredsstillende oppstart av ny operasjon på samme stue?

Eventuelle personalgrupper som har for mange baller i luften og som derfor stadig må ventes på?

Hvordan har seksjoneringen påvirket dette?

<u>Spørsmål 4 Kapasitet andre personellgrupper</u>

Hvordan påvirker kapasiteten innenfor merkantilfunksjoner, renhold og portørtjenester pasientflyten i SOP?

Hvordan har seksjoneringen påvirket dette?

<u>Spørsmål 5 Fysiske forhold i SOP eller utstyrsmangel som påvirker pasientflyten?</u>

Hva er bra

- Assistentene trives på dagtid, de har god kjennskap til folk og utstyr på grunn av seksjonering og føler tilhørighet til seksjon. Dette gjør at arbeidet går lettere og at de vet hvor ting skal på sin seksjon.

Hva kan gjøres bedre

- Innslusing er fremdeles et problem. Innføring av navn på dørene har ført til en liten bedring, men 3 sluser er for lite i forhold til kapasiteten på SOP og det blir opphoping på gangen. Mer en tre sluser for å kunne få en tidligere oppstart. For lite med 1 sluse til recovery.

- Drift tar ikke hensyn til at opplæring skal gjennomføres. Det blir ikke tatt hensyn til at dette fører til lengre tidsbruk.
- Det vaskes for lite på grunn av at neste pasient står klar til å komme inn på stuen og assistentene får for liten tid.

- Assistentene på vakttid har mindre kjennskap til de andre seksjonene. Siden de er i stor grad seksjonert kjenner de ulike veldig godt til sin seksjon. Problemet er om kveld/helg når det er en som har ansvar for hele SOP. Assistenten har liten kjennskap til andre seksjoner angående utstyr osv.
- Få assistenter gjør at de får mindre tid til å pakke utstyr og operasjonssykepleierne får mer å gjøre. Dette gjør at flyten går tregere. (*Dette gleder mer generelt*)
- Forlenging av elektive program fører til verre arbeidssituasjon for portører, kan hindre flyt. Prioritering av stuer, men de på stuene må gjøre mer selv. Portører er ikke seksjonert, men jobber på alle seksjonene. De føler at det er blitt mer arbeid etter seksjoneringen på grunn av at det elektive programmet pågår lenger. Om kveld/ettermiddag er de kun to portører. De fleste stuene er også mer eller mindre ferdig samtidig noe som fører til en opphoping av arbeid (bord, senger, utstyr osv) som da to portører skal ta seg av.
- For lite med en sluse til recovery, skaper køer i gangen og at operasjonssykepleier kommer sent i gang med lunsj og sent tilbake fra lunsj og det har ringvirkninger på de andre sine lunsjer osv.
- Oppstart av dagkirurg har ført til færre kirurger på SOP.
- Må ha oppdaterte prosedyrebøker (*dette er fagansvarlig sin arbeidsoppgave, men de er opptatt med klinisk- arbeid*)
- For lite operasjonssykepleiere og anestesisykepleiere fører til unødvendig stress og økende sykdomsfravær.
- Det trengs faste avløsere slike at fagansvarligsykepleier ikke brukes som avløsere. Dersom en fagansvarlig sykepleier er vekke er det en andre som må steppe inn for begge. Før seksjoneringen hadde disse ”assisterende” operasjonssykepleiere som kunne ta over arbeidsoppgavene når en var vekke.
- Planlegging for fremtiden, ved at de på kirurgisk, og da først og fremst operasjonssykepleierne og anestesisykepleierne, har en høy gjennomsnittsalder. Hvem skal erstatte de? Det tar flere år før en operasjonssykepleier kan fungere optimalt og opplæring tar tid.

Bemanning beredskap.

- Det er ingen ledig på anestesisiden til å ta akutt calling fordi de skal avløse de på stuene og har i tillegg andre arbeidsoppgaver. Det er ingen som hele tiden er ledig fordi samme personen helst skal være på tre steder samtidig. Det er her opp til en enkelte å prioritere hvilke arbeidsoppgaver som skal gjøres da det ikke eksisterer noen retningslinjer i disse tilfellene.
- Det er ikke blitt bedre bemanning eller beredskap.
- Vaktbelastningen er blitt verre i tillegg til mer overtid. Daglig overtid der personalet blir spurt sent på dagen om å jobbe overtid sliter på de ansatte/skaper irritasjon og skaper problemer for de ansatte når det gjelder endring av planer på fritiden.
- Det bli ikke tatt høyde for opplæring av personalet i drift.
- Plunder og heft om morningen på grunn av leting etter utstyr som er felles for alle seksjonene. Det er ingen som har ansvar for vedlikehold og plassering av utstyr som armbord, madrasser osv. Dette medfører at personalet må lete etter utstyr og mye tid går vekk. Det er dårlig vedlikeholdt og må bli mer tilgjengelig for personalet.

- Fagsykepleierne må få tid til å gjøre oppgaver relatert til fagsykepleiernes rolle. Det er pr i dag en dårlig oversikt over ustyr og vedlikehold av ustyr osv. Dette er noe personalet lider av i dag.
- Det er litt av den samme tendensen på anestesi. Det er en som bestiller medikamenter og når hun er vekke er det ingen andre som gjør denne jobben / eller det blir mer tilfeldig. (*dvs. de mangler et sikkerhetsnett angående nøkkelpersoner*).

Seksjonering på vakttid:

- Det kan bli en risiko ved at anestesisykepleierne må hjelpe til på andre seksjoner fordi de i større grad er blitt spesialiserte på sin seksjon. De har etter seksjoneringen en mindre sjanse for å få opprettholdt en tverrfaglig kompetanse.
- Assistenten har det samme problemet angående utstyr.

Annet

- Vanskelig situasjon på grunn av mange problemer etter seksjoneringen, men de prøver å gjøre det beste ut av situasjonen.
- Har løsninger, men føler at de ikke blir hørt. Det er frustrerende når en prøver å opplyse om feil/problemer for så å blir overkjørt av at alt er ok.
- Mange gidder ikke å si i fra om feil på grunn av at ingen endringer skjer.
- Ivaretakelse av personalet og deres arbeidssituasjon og miljø bli ikke vektlagt.

KSK i omstilling
Seksjonsledere/brukere leger/rådgivere/Overleger/kontaktpersoner/

Det vil i de kommende årene ikke være noen økning av personalressurser på Haukeland da de siste 5 årene har det vært en stor økning av personale.

Det er i dag ønskelig med en justering av seksjoneringen ut i fra slik den er i dag.

<u>Spørsmål 1</u>
Hva er blitt bedre og hva er blitt dårligere etter siste seksjonering i SOP sett ut fra:
KSK (ledelsesmessig og for de ulike yrkesgrupper)
Den enkelte brukerklinikk

Mht.

1. Planlegging/forberedelse til operasjon
2. Kommunikasjon/samarbeid
   a. Hvordan sikres at de ulike interessenter i SOP samhandler for en for pasienten optimal måte?
3. Kapasitet
   a. Bemanning – planlagt aktivitet
   b. Bemanning – beredskap
4. Kvalitet
5. Annet

Hva er bra
<u>Personale</u>

- Operasjonssykepleierne kjenner de ulike kirurgene bedre.

- Mer veltrent personell, de vet hvor ting er osv.
- Bedring av kvalitet (operasjonssiden) fordi personalet på de ulike seksjonene kan mer. Det er ikke alle seksjonene som har merket denne endringen.
- De på SOP har mye å gjøre, men trives på jobb (*operasjonssykepleiere*).
- Har faste anestesileger og faste folk, færre mennesker å forholde seg til.
- Bedre kontakt mellom yrkesgruppene på SOP (operasjonssykepleiere, anestesisykepleiere, assistenter osv).
- Lettere å kommunisere
- Kortere kommunikasjonsveier
- Det er nok leger/operatører.
- Personalet er blitt bedre på de som de holder på med på sin seksjon. (operasjonstyper osv)

Beredskap

- Bedre beredskap har ført til mindre ventetid for pasientene som igjen har økt kvaliteten til pasienten.

Planlegging

- Orbit har ført til en forbedring angående planlegging av operasjoner.
- Bedre i forhold til nedtrekk/ nedtrekks-perioder (når det er full aktivitet og når den er redusert). Bedre planlegging i forhold til turnus og det er lettere å komme brukeravdelingene i møte.(*sett fra ledelsens sin side*)
- Bedre forutisbarhet i planleggingen. Seksjoneringen har før til at det er færre folk å forholde seg til noe som har gjort planleggingen lettere og bedre.
- Brukere: har ikke hatt noen stor endring i daglig planlegging.
- Færre strykninger, sjeldnere strykning på grunn av at en mangler operasjon stue.
- Bedre planlegging/forberedelse til operasjoner spesielt fra ledelsens side.
- Lettere å ta avgjørelser.
- Lettere drift på grunn av lettere planlegging.

Ressursutnyttelse

- Bedre fleksibilitet angående for eksempel bytting av stuer.
- Bra med aktiv beredskap fram til kl 22 på kveldstid (*sjekk om klokkeslettet er rett*), men har ikke råd til dette i helg.
- Bedre forutsigbarhet når det gjelder ressurser.
- Konkurrerer med færre for å få stue til å utføre ØH -operasjoner.
- Prioritering av egne pasienter internt. Seksjonene kan prioritere/konkurrere innenfor egen seksjon om hvilke pasienter som skal opereres først osv.
- Bedre ressursstyring.
- Bedre opplegg på preopr. Pasientene kan i større grad komme selv til SOP. Det er et mer differensiert opplegg.
- Bedre kompetanse på ØH (*dette tror jeg er sekjonsavhengig*).
- Kvalitets forbedring blant annet på grunn av pasientene opereres raskere, noe som fører til mindre ventetid for pasienten.
- Bedret kommunikasjon/samarbeid.
- Beredskapen er i dag mer opp til den enkelte seksjon når det gjelder justeringer (*om dette er positivt eller negativt kommer nok seksjonsavhengig*).

- Bedre budsjettstyring/ kontroll over budsjett

Hva kan gjøres bedre

Personell/ressurser

- Kan ikke bruke ledig kapasitet/personell på grunn av regler.
- Ingen forpliktelser angående å støtte andre seksjoner. Mindre muligheter for "lån " av personalet, mindre fleksibilitet.
- Støttefunksjonene: ingen bedring i fleksibiliteten dvs. operasjonssykepleiere og andre ledige ressurser hjelper ikke alltid til dersom de er ledige med for eksempel pakking av utstyr.
- Anestesisykepleierne er mer spesialiserte, dette har ført til problemer når de skal hjelpe til på andre seksjoner.
- Oppsamlinger av pasienter etter helg. Det blir her i noen tilfeller brukt overtid, men dette er en belastning for personalet/ overbelastning - sykemelding. Oppsamlingen av pasienter etter helg gjør at en må begynne uken med å prøve å få unna disse pasientene, men i tillegg har en dagprogram- pasienter. (*kan dette gjøre at mange elektive operasjoner blir strøket tidelig i uken?? Sjekk dette.*)
- Det er for få operasjonssykepleiere
- Det er blitt laget "høye vegger" mellom seksjonene noe som har ført til at en ikke får utnyttet ressursene godt nok der det er muligheter for det. (*tror dette gjelder spesielt helt og kveld*).
- Mangel på anestesileger.
- En er personlig ansvarlig for strykning av operasjoner. Dette har gjort at tidsbruk på fagligutvikling/kompetanseutvikling har gått ned. Det er i dag liten ivaretakelse på kompetanseutvikling fordi en bruker "den ene" ledige operasjon/anestesissykepleieren til å gjennomføre en operasjon istedenfor å stryke.
- Medisinsk koordinator er mer diffus nå, bruker den mindre på Hode/hals (*hvilke konsekvenser har det??)*
- Ledelsesteam og deres arbeidsoppgaver er litt diffust. Det er vanskelig å få dette teamet til å virke. Seksjonsleder har et overordnet ansvar for seksjonen, mens lederteamet er mer rettet mot det faglige dvs. ikke nok utviklet i den rettingen som er ønskelig.
- Anestesi vil helst ikke seksjoneres, men holde på matrisemodellen.
- Assistenter og portører ønsker å i større grad få hjelp av operasjonssykepleiere når det gjelder utstyr. De peker på at det er ikke alle seksjoner som er like presset og disse ressursene kan bli brukt. Operasjonssykepleierne mener at de bruker mer tid/ressurser på utstyr enn det som er gunstig i forhold til andre arbeidsoppgaver som operasjonssykepleierne har. De ønsker heller en økning av assistent/støtte personalet.

Kapasitet/aktivitet

- Kapasiteten på ØH er ikke bedret.
- Ingen større kapasitet.
- Kapasitet utnyttelsen og lån av stuer kan føre til stryk, eksempelvis når brann låner en ½ stue en dag så får ingen andre brukt stuen. (*på grunn av tidsbruk/forlengelse av inngrepp fra brann sin side???*)

- Ingen anledning til å operere flere ØH pasienter. De som må opereres blir operert. Ingen økt aktivitet (OT).
- Noen seksjoner: dårlig kapasitet på ØH. Bedre beredskap på dagen har ført til at noen seksjoner får unna sine ØH pasienter og det har igjen ført til mindre nattoperasjoner, men andre seksjoner venter med sine ØH pasienter til kveld og natt.
- Ingen økt kapasitet. Stuetallet i uken har økt og det samme har kveld, men samtidig har pasientenes behandlings behov blitt mer komplisert. (Dette vil si atktiviteten/antall operasjoner ikke har økt i like stor grad).
- Fremdeles problemer med å få unna ØH pasienter. (*For OT er dette letter fordi de styrer det mer selv ved at de har egen Øh stue*).

Annet

- Bedring av bruken av Orbit, bedre utfylling av Orbit generelt.
- Kortene blir benyttet fordi det er det enkleste, men det gjør at en av og til ikke gir utfyllende informasjon på Orbit. Operasjonskortene er ikke alltid tilstrekklig/ bør differensieres mer.
- Hode/hals er ikke helt seksjonert.
- Multitraume pasienter er en utfordring.
- Dårligere angående bred erfaring blant personalet, vanskeligere når det er multitraume pasienter.
- Sein knivstart.

Beredskap

- Det er her uenigheter om det har blitt en bedring eller ikke. For OT har det for eksempel blitt en bedring av beredskap i uken, men ikke i helg. Må la folk gå i utrykning og det sliter på personellet *(Det er bedre utnyttelse av personell i andre seksjoner i helg).*
- Beredskap/vakt begynner å gå seg til ved at en hjelper over seksjoner.

Spørsmål 2

Grunnlag for at SOP skal fortsette som en stor enhet i forhold til ulike seksjoner.

- Det er i dag ingen stordrifts fordeler/muligheter med SOP. Det optimale er å ha 3-6 stuer og at det blir styrt som en enhet. Det er få fordeler som utstyrsinnkjøp osv. disse fordelene er små i forhold til fordeler ved en hel-seksjonering.

- En fordel som ble på pekt er SOP bakvakt som dekker mye av den operative virksomheten på kveld/helg/natt. Men dette kan taes vekk ved at en har en operativenhet knyttet opp i mot akuttmottak av pasient.

Annet

- De som har lite å gjøre på kveld/helg kan i større grad bruke hjemmevakt. (Thorax får *her hjelp på 0-prioriterte pasienter på kveld og helg, har her hjemmevakt*).
- Enda større seksjonering angående beredskap/vakt.

- Anestesifaget felles for SOP, men da må en holde på matrise modellen og ikke splitte det mer opp. En oppsplitting vil føre til at det blir nødvendig med økning av mannskap. Anestesisykepleierne har større virkemåte kveld/helg.
- Det er lange transportveier til SOP. I mer moderne sykehus er de operative enhetene mer nærliggende til sengepost og postoperativ seksjon.

Pilot prosjekt
På OT har de en menig og en matros i opplæring innenfor støttefunksjoner/portører. De skal jobbe på OT i et halvt år og blir ikke lønnet av OT, men får attest på gjennomgått opplæring og erfaring. Det går en del ressurser til opplæring, men de blir en god ressurs.

Forholdet bruker- SOP
- Det er ikke bare i SOP det ligger problemer. Det ble etterlyst at også brukerne i større grad skulle prøve å løse sine problemer i forhold til SOP som for eksempel oppmøte på stuer, planlegging, utnyttelse av SOP, kommunikasjon som å ha oppmøte på tverrfaglige møter mellom SOP- brukere.
- Økning av seksjoneringen til å omfatte brukerne også.

Ulike forslag
- Total seksjonering av alt personale på SOP. Assistentene er tilhørende dvs. har sine faste seksjoner på dagtid. Dette gjør det vanskelig for assistentene på kveld/helg fordi de da må dekke hele SOP. Selv om de har vært innom seksjonen tidligere er det vanskelig på grunn av endringen og en økende mengde utstyr osv. Dersom de skal seksjoneres må antall assistenter økes. (*Portører er heller ikke seksjonert, men de er heller ikke tilhørende til faste seksjoner*).

(KSK har allmennbevilgning mens de kirurgiske seksjonene for igjen gjennom DRG).

KSK i omstilling, Gruppeintervju Thorax 16.1104

Anmerkninger i kursiv er egne bemerkninger eller elementer som er usikkre.
Forventinger
I utgangspunktet hadde de mange av de som deltok på samlingen ingen forventinger til at det skulle komme ut noe nytt. Det ble uttalt at hovedgrunnen til at gruppeintervjuet fant sted var økonomi.

Det kom fram at Thorax har jevnlige møter sammen hver mandag der de tar opp ulike problemer angående seksjonen.

Det er forventet en endring av økonomistyring angående pasienter som kan føre til en økt konkurranse om pasientene av den grunn at pengene skal i større grad følge pasienten. Dette vil si at de må bedre vise fram kvaliteten av arbeidet som de utfører.

Thorax ligger pr i dag under det behovet som er i regionen.

Når det gjelder planlegging av Thorax (*eventuelle endringer*) ser de på det som viktig å også se på Postop fordi det er en del av pasientflyten gjennom seksjonen.

Det ble gitt uttrykk for en positiv innstilling til seksjoneringen og at den har ført til økt kvalitet og bedre ressursbruk. Thorax har vært seksjonert lengre enn de andre seksjonene på SOP. (*Thorax har rundt 30-40 øh. pasienter i året mens den elektive virksomheten er rundt 600-700, må sjekke om jeg oppfattet dette rett*).

Planlegging/ forberedelse til operasjon

Spørsmål 1

Hvordan fungerer dagens planlegging av operasjonsaktivitet i forhold til de enkelte yrkesgruppers behov for å forbedre egen innsats innenfor:

e) ØH-aktivitet?
f) Elektiv virksomhet?

Hvordan har seksjoneringen påvirket dette?

Hva er bra

- Vedrørende elektive pasienter blir det sett på som positivt at det samme personalet følger pasienten gjennom flyten.
- Det er blitt en bedring i beredskapen på ØH.
- Det er blitt en bedring i langsiktig planlegging for eksempel ved at ingen planlegger kurs som gjør at personalet på SOP blir gående uten operatør og slik ikke får gjennomført operasjoner.

Hva kan bli bedre

- Orbit som planleggingsverktøy, og Pax web. Det ble sagt at operasjonskortene i Orbit må oppdateres/ bedre differensiering av operasjonstyper. Som utgangspunkt kunne akseptskjemaene brukes. Risikovurderingen av pasienter burde også bedres. Det blir i dag i brukt ”Elroscore” for å regne ut risikoen for pasienten ved å gjennomføre operasjon og det ble savnet noe tilsvarende eller en mer detaljert risikobeskrivelse i Orbit.
- Større kapasitet på pc-ene da det ofte tar lang tid å hente opp data.
- Flere pc-er, da det ofte er kø om å komme til på pc-ene.
- Bedre kommunikasjon mellom SOP og sengepost.
- Fleksibiliteten på grunn av snevre personalrammer og regler for vakter.

Kommunikasjon og samarbeid

Spørsmål 1 Kirurgi –SOP (Orbit, melding av pasient)

Får anestesilege, anestesi- og operasjonssykepleiere tidsnok, korrekt og fullstendig nok informasjon til en optimal planlegging og gjennomføring av sine oppgaver?

Hvordan har seksjoneringen påvirket dette?

Spørsmål 2 Anestesilege/anestesisykepleiere/operasjonssykepleiere

Hvordan fungerer dagens kommunikasjon og samarbeid omkring alle oppgavene som skal utføres før kirurgien skal begynne?

Hvordan har seksjoneringen påvirket dette?

Hvordan har organiseringen av operasjons- og anestesisykepleiere under èn, felles leder påvirket samarbeidet mellom og koordineringen av disse to gruppene?

Spørsmål 3 kommunikasjon SOP- sengepost
Er personalet i SOP og ved sengepost tilstrekkelig tilgjenglige for hverandre for å avklare dagens mange spørsmål?

Hvordan har seksjoneringen påvirket dette?

Hva er bra
Spørsmål 2

- Både anestesi og operasjonssykepleierne, og portører, assistenter har jevnlige møter der de tar opp ulike elementer.
- De har også andre tverrfaglige møter og syntes at etter seksjoneringen har denne kommunikasjonen blitt bedre.
- Det har blitt en økt kjennskap til pasient kjeden.
- Bedre kommunikasjon på grunn av fast personale

Spørsmål 3

- Bra kommunikasjon mellom avdelingsledere og post.

Hva kan bli bedre
Spørsmål 1

- Se angående Orbit på planlegging

Spørsmål 2

- Finpussing mellom kommunikasjon til post, at det er ledere eller de ansvarlige som formidler informasjon for å unngå missforståelser.
- Ledere har et forbedringspotensial angående kommunikasjon

Kapasitet
Spørsmål 3 oppstart om morgenen og tid mellom operasjoner
Hvilke faktorer utover god kommunikasjon og god planlegging er kritiske for

e) Tidligst mulig oppstart om morgenen og
f) Rask og samtidig faglig tilfredsstillende oppstart av ny operasjon på samme stue?

Eventuelle personalgrupper som har for mange baller i luften og som derfor stadig må ventes på?

Hvordan har seksjoneringen påvirket dette?

Spørsmål 4 Kapasitet andre personellgrupper
Hvordan påvirker kapasiteten innenfor merkantilfunksjoner, renhold og portørtjenester pasientflyten i SOP?

Hvordan har seksjoneringen påvirket dette?

Spørsmål 5 Fysiske forhold i SOP eller utstyrsmangel som påvirker pasientflyten?

Hva er bra
Spørsmål 2

- Meget god beredskap kveld/natt og helg.

Hva kan bli bedre
Spørsmål 1

- Sykdom (dvs. av personale eller innenfor familie eventuelle andre forfall) kan føre til at en operasjonsstue blir tatt ut av drift eller at operasjoner blir strøket. De gav uttykk for at de er veldig sårbare overfor sykdom når det gjelder operatør siden, men også innenfor andre personalgrupper. Forfall i ferieperioder får negative konsekvenser. (*En løsning her kan være å ta i bruk personale på postop*).

Spørsmål 2

- Tilkalling av beredskap kan bli bedre, da beredskapen kan bli tilkalt uten at det er nødvendig eller at de blir tilkalt for seint. Det at en venter med tilkalling på beredskapen kan føre til at de som er på vakt føler at situasjonen er mer stresset.

- Det blir stilt spørsmål med at uerfarne personale må ha opplæring inne på Thorax når det ikke vil være den seksjonen de skal jobbe på.

Spørsmål 4

- Assistenter/portører må i større grad taes i betraktning når operasjoner skal planlegges. De føler seg ofte overkjørt ved at personalet står utenfor stuen og presser på for å komme inn på stuen. Programmet går uavhengig av hvor mange assistenter eller portører som er tilstede på SOP.

Kvalitet/ annet
Hvilke forhold ved dagens SOP- organisering styrker behandlingskvaliteten i pasienten forløp i SOP?

Hvilke forhold kan og eventuelt må forberedes for å styrke kvaliteten?

Hva er bra

- Det ble gitt uttrykk for at seksjoneringen har ført til en bedring angående stuer. Hver seksjon har sine bestemte stuer der pasienten kommer til stue og personalet slipper å komme til ulike stuer og frakte nødvendig utstyr med seg.
- Det er kvalifiserte personer på jobb

Hva kan blir bedre

Annet

- Kvaliteten måles pr i dag i komplikasjoner og død.
- Det er en skjevhet i etterspørsel – behov.
- Ventelisten er pr i dag i balanse.
- Kompetanse og erfaring har noe å si for effektiviteten.

7.4 Appendix F: Summary of gathered information through interviews at Haukeland Universitets sykehus.

- Det er tre innslusings muligheter. Der i fra blir pasienten fraktet til innlednings rom. Det er et innledningsrom på to stuer. Det vil si at OT har to innledningsrom .

- Det er stue 7 som er Ø.H. stue.

- På dagtid er det to operasjonssykepleiere fast. De får hver sin rolle en er løsgjenger/koordinering og den andre er stril på stue. Operasjonssykepleierne er delt inn i at det er en fagansvarlig pr stue. De to operasjonssykepleierne er det inn ved at en er løsgjenger/koordinator og en er sterilt

- Kl åtte kommer operasjonssykepleierne på jobb. Der blir de orientert om pasienter som har blitt forberedt og som skal opereres kl åtte.

- Operasjonssykepleier er sjelden med på innslusing av pasient.

- Ved avslutning av operasjon er det sterilt som rydder vekk utstyr osv. på stue og løsgjenger som sluser ut pasient. Den sterile går til en ny operasjon, eller eventuelt til pause og løsgjenger tar over.

- Løsgjenger begynner så å klargjøre en ny operasjon etter at en ny pasient har kommet inn på stuen.

- Når en operasjon er startet begynner de med å forberede en ny operasjon. Stuene gir beskjed om hvor lang tid, sånn cirka, de har igjen av operasjon. En ny pasient blir da hentet ned alt ut i fra hvilken stue som er klar raskest, og blir slust inn og kommer på innledning. Det er kun den tiden det tar å vaske stuen før en ny pasient er på stuen.

- Siden det aldri blir utført samme operasjon etter hverandre må utstyret fra stuen byttes ut etter hver operasjon. Dette ville ha blitt lettere dersom den samme type operasjon ble utført etter hverandre fordi det da ble brukt mindre tid på klargjøring av stue. Dette har med kirurgene og deres bestilling av operasjoner å gjøre. Det at spesialister skal kunne passe en operasjon inn i sin dagsplan. SOP er her kontrakt bundet med å gi tjenestene sine til kliniske avd.

- Det er 2 *3 operasjonssykepleiere pr stue og en mellomvakt fra 12 til 19.00 som gjør at alle får de pausene som de skal ha.

- 07.30 til 15.30 fra 15.30 til 22.45 også er det hjemmevakt fra 22.45 til 07.30

- I helg er det lørdag: 09.00 til 18.00 og hjemmevakt fra 18.00 til 09.00

- Søndag er det 09.00 – 18.00 og hjemmevakt til 07.30
- De som jobber helg skal ha en dag fri før og en dag fri etter en helgevakt. Det utgjør to operasjonssykepleiere og 1 anestesisykepleiere det vil si 5*2 = 10 dager noe som utgjør 2 årsverk.
- Dersom heleskiftene skulle utvides med et team ville dette har ført til 4 operasjonssykepleiere og 4 anestesisykepleiere det vil si 8*2 = 16 dager
- Slik det er i dag tilfredsstiller ikke helgeskiftene behovet, men å ha et skift til eller et team til vil koste for mye med tanke på hvor mange som er ansatt av personell på OT. Det forkommer at operasjoner blir utført etter kl 18 i helgene dersom det er nødvendig. I helgene er det 9 timer aktiv vakt.
- Fagsykepleier er med på forberedelse operasjon, men er ellers kun pasientrelatert i tilknytting til pauser hvor hun stepper inn og tar over for operasjonssykepleierne.
- Fagansvarlig operasjon er kun med på forberedelse av operasjon, hun kan erstatte en operasjonssykepleier og går da inn i operasjonssykepleierens rolle.
- Operasjonssykepleier fagansvarlig er med fra operasjons siden, mens fagansvarlig anestesi trenger nødvendigvisk ikke, men kan holde på med andre arb.oppgaver som ikke er pasient tilknyttet.
- Alle anestesisykepleierne begynner halv åtte. Da kommer det 5 stykker som begynner å forberede til operasjoner. Det er en til hver stue (sterile) og en som er ansvarlig for to stuer og en som er ansvarlig for en stue(innledning og innslusing).
- Om morningen sluses tre inn med en gang der to går på innledning og den med høyest ASA prioritet går rett til stue.
- Det er anestesisykepleiere som sluser inn pasienter. De innkaller hjelp dersom det er nødvendig. De får da en sjekkliste med pasienten. Mottakket blir registrert i Orbit dvs. at innslusingstid blir registrert i Orbit.
- Anestesisykepleierne er delt inn i to roller. Det er en som er ansvarlig for to stuer (7 Ø.H. stuen og 8 elektiv), mens den andre har ansvar for en stue. De to er ansvarlige for anestesisykepleiere. En anestesisykepleier er på stue og det fører til en fin flyt. Mens anestesisykepleier ansvarlig er for (innslusing og forberedelse anestesi).
- Den ansvarlige bruker mye tid på papirarbeid forbundet med pasienten og til å sjekke at papirene er i orden. Og samarbeider med anestesilege om

medikament bruk for pasienten. Det er kirurgen som skriver operasjonsrekvisisjonen og setter da opp ”ønsket” medikament bruk/bedøvelse for pasienten. Anestesisykepleieren forbereder dette til operasjonen, men når anestesilegen ankommer har han kanskje andre ønsker og da må anestesissykepleierne gjøre klar den nye medikamentene.

- Anestesisykepleier ansvarlig erstatter de på stue slik at de kan få pauser.
- Nei, det er en anesykepeier som sluser inn og er med på innledning også er det en annen som er med op operasjon og avslutning.
- Dersom portøren er opptatt så stepper operasjon sykepleierer eller en annen som er ledig inn og hjelper til. Det er portørene som er flinkest når det gjelder leie av pasienter. Portøren er med når det gjelder leie av pasienten. Når det er akutte pasienter må ofte leie improviseres. Det er også slik at ofte er det spesielle tilfeller som gjør at spesielle leier trengs.
- En øyeblikkelig hjelp pasient er en pasient som skal opereres innen 24 timer. På OT er det litt spesielt fordi en øyeblikkelig hjelp pasient ikke nødvendigvis trenger å bli operert innen 24 timer, men kan vente så lenge som en uke. (pasienten vil da ligge på sykehuset)
- En akutt pasient er det samme som en øyeblikkelig hjelp pasient. Ø.H pasienter får tildelt ulike prioriteringer der 0- prioritet pasienter er pasienter som har størst prioritet og skal opereres først. Etter det kommer 1-, 2- osv prioritet.
- Det er flere grunner at en pasient med høyere prioritet dvs. større komplikasjoner må opereres først og at pasienten slik blir skjøvet ned på Ø.H. listen.Det kan komme av kapasitet begrensninger, (antall team og ledige stuer).Den medisinsk ansvarlige kirurgen gjør hele tiden vurderinger av situasjoner til ventende og innkommende pasienter og kan slik gjøre at en pasient må vente utover anbefalt operasjonstid.
- Ø.H. pasienter blir liggende på sykehuset mens elektive kan bli sendt hjem. Dette fordi at elektive operasjoner er planlagt og programmet kan være planlagt i uker i forveien.
- Forberede operasjon foregår helt fra bestilling og til kirurgen kan sette i gang med operasjonen, knivstart. Operasjonssykepleier, anestesisykepleier, operatør og anestesilege, assistenter (portører) er de personalgruppene som er med på

forberedelsen. Pasienten ligger på klinisk avdeling under forberedelsen av operasjonen.

- Under innslusing blir det sjekket at pasientene har de rette Id- papirene med seg og at de rette rapportene fra pre medisin, som anestesisykepleieren trenger er med. Det blir også sjekket at de rette papirene følger med pasienten inn i stuen. Pasienten blir lagt opp over på operasjonsbordet og den rette oppstøttingen og tildekning av pasienten blir foretatt.
- Det er tre sluser. Nå holder der på med en prøveordning der de ulike seksjonene har sine bestemte sluser, og der de setter slusene til ledige slik at andre seksjonene kan benytte dem dersom den bestemte seksjonen ikke benytter seg av slusen.
- Thorax har ikke lik oppstart som de andre seksjonene ved at de starter en halv time før de andre seksjonene.
- Pasienten kan være forsinket ved at pasienten trenger mer tid til å gjøre seg klar til operasjonen, toalettbesøk, hygiene, overflytting osv. Venting kan også forekomme på grunn av manglende ressurser på de ulike avdelingene og at pasienten derfor ikke er klar til operasjonen i tide. Det kan også forekomme at kommunikasjonen mellom de ulike avdelingene ikke er god og at det oppstår misforståelser ved at prioritering av pasienter forandres gjennom dagen og at dette ikke blir formiddlet videre eller at avdelingene ikke er klar over at det har skjedd en endring av operasjonsrekkefølgene. Dette kan forekomme på grunn av kunnskapsmangel ved at de ulike ansatte på de ulike seksjonene ikke har tilstrekkelig kunnskap om ulike pasient systemene. Det er også stor utbytting av personell på klinisk avdeling noe som kan føre til at dersom det er blitt opprettet en god kommunikasjon mellom operasjonsavdelingen og personell på klinisk avdeling kan denne forsvinne dersom personalet slutter på avdelingen.
- Forberedelsen begynner før pasienten kommer ned til operasjonsavdelingen. Det blir jobbet parallelt med forberedelser og operasjon. Dette blir gjort til alle de tre stuene. Det er den fagansvarlige sykepleieren som sammen med operasjonssykepleiere og anestesisykepleiere som klargjør for operasjon. Etter klargjøring av en operasjon begynner en på å klargjøre for neste. Dette gjør at en jobber parallelt med operasjon av pasient og gjør at det ikke er noe dødtid.

Det er et mål for OT å ikke ha noe dødtid blant de ansatte og mellom operasjoner. Forberedelsene går på å klargjøre utstyret for operasjonen, forsikre at det er bemanning for å utføre operasjonen.

- For den første pasienten begynner de med forberedelsene 20 minutter før pasienten ankommer stuen. Neste pasient forberedelses skjer overlappende /parallelt arbeid for å forberede innledning.
- Det er en anestesioverlege og en assistent. Det er en anestesilege på to stuer dvs. to på tre stuer.
- Det er anestesisykepleieren som avlegger rapporten til personalet på recovery. Operasjonssykepleieren blir med dersom det er snakk om tunge løft ellers så skriver disse sin rapport i Orbit. Operatøren gi informasjon til anestesisykepleieren som da viderefører denne.
- Hva blir gjort under utslusingen av pasienten?Pasienten blir overført til en ny seng og pasienten blir sjekket for at alt er i orden. Dersom det er snakk om dren blir disse sjekket og at pasienten ligger slik som den skal.
- Recovery har en utsluse, dette kan føre til ventetid utenfor slusen fordi det kun er en sluse og alle pasientene som skal på recovery skal gjennom denne. For pasienter som ikke skal på recovery blir de slust ut gjennom innslusene. Men her er det mindre ventetid og ventetid blir ikke sett på som et problem.
- Det er anestesisykepleier og operasjonssykepleier som sluser pasienten ut av stuen. Anestesisykepleieren tar med pasienten til recovery også recovery personalet er med på å hente pasienten til recovery
- Assistenter og portører står for det meste av vaskingen av stuene, mens operasjonssykepleierne og anestesisykepleiere klargjør for en ny operasjon.
- På OT er det alltid ulike operasjoner etter hverandre, den samme operasjonen blir ikke utført etter hverandre på samme stue.
- Operatøren kan også komme forsinket ved at det er uenighet om hvem som skal vente, operastøren eller de ansatte på operasjonsavdelingen. Et mål er å ikke ha noen dødtid, men når de er ferdig med å forberede pasienten kan de ikke gjøre annet enn å vente på operatøren. Men operatøren har mange oppgaver som ikke omfatter operasjonsavdelingen og liker ikke å bli kalt ned for tidelig for da må han vente og blir ikke ferdig med sitt egent program.

- 2,33 operasjonssykepleiere, 1-3 kirurger, 11/2 anestesisykepleier og ½ anestesilege. Den 0.33 operasjonssykepleieren er med på å hjelpe til med klargjøring av operasjonen, det er den ekstra halve sykepleieren).
- Seksjonsleder, anestesisykepleier, fagansvarligsykepleier og to operasjonssykepleiere begynner kl 07.30. De begynner med å forberede til operasjonene. Kl 08.00 begynner de andre på operasjonsavdelingen. De jobber fram til kl 15.30
- Under ferier er det færre stuer i drift. Det blir beregnet til ni uker med nedsatt bemanning og stueaktivitet. Det blir også leid inn vikarer, men folk er flinke til å justere feriene sine slik at de ikke treffer på perioder med mye trafikk til sykehuset. I ferier er det en stue til elektive operasjoner og en til Ø.H. (dersom jeg husker rett så er det alltid en stue med Ø.H mens det i sommer månedene blir mindre elektiv aktivitet).